

OKLAHOMA HPR-1(5)

RESEARCH PROJECT No. 68-07-3

CONTINUED EVALUATION OF
ROADSIDE DEVELOPMENT AND EROSION CONTROL EXPERIMENTS

Supplemental Report

- Part I. Causes and Control of Soil Erosion
on Oklahoma Highways
- Part II. Maintenance of Vegetative Ground Covers
on Oklahoma Highways
- Part III. Weed Control and Eradication on
Oklahoma Highways

by

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in cooperation with

The Oklahoma Department of Highways

and

The United States Department of Transportation

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Oklahoma Agricultural Experiment Station

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"The opinions, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the Oklahoma Department of Highways or the Bureau of Public Roads."

CONTINUED EVALUATION OF
ROADSIDE DEVELOPMENT AND EROSION CONTROL EXPERIMENTS

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RECOMMENDATIONS

The recommendations contained in this report are a supplement to and in agreement with those contained in the Final Report of Oklahoma Project No. 63-03-3, Parts I, II, and III. Although the research in this project concerns the common investigation of Roadside Development and Erosion Control the results will be presented as three separate investigations for the purpose of clarity and convenience.

PART I

CONTROL OF SOIL EROSION ON OKLAHOMA HIGHWAYS

1. Weeping lovegrass seems to be more widely adapted and easier to establish for erosion control in Oklahoma than other species tested. Its use in western, central, and eastern Oklahoma is to be encouraged until such time a more satisfactory grass becomes available.
2. Based on limited research data no significant benefit could be detected from the incorporation of lime into the soil, or tillage either by disking or with a chisel, prior to seeding bermudagrass for erosion control on a north or west facing backslope. These practices are not to be encouraged until and unless future research proves them beneficial under other conditions or for other plants.
3. Those recommendations on pages vii and viii of the Final Report of Oklahoma Project No. 63-03-3, Roadside Development and Erosion Control, Part I on "Causes and Control of Soil Erosion on Oklahoma Highways" are cited and supported by these data.

PART II

MAINTENANCE OF VEGETATIVE GROUND COVERS

1. Fertilization

a. East of US-81

1. General for ALL GRASS MIXTURES ON ALL SLOPES. The frequency of fertilization for maintenance of erosion resistant ground covers is indicated by these data to be every other year, especially when bermudagrass is present.
2. Those recommendations on pages viii and ix of the Final Report of Oklahoma Project No. 63-03-3, Roadside Development and Erosion Control, Part II on "Maintenance of Vegetative Ground Covers on Oklahoma Highways" are cited and supported by these data.

b. West of US-81

1. General for ALL GRASS MIXTURES ON ALL SLOPES. The frequency of fertilization for maintenance of erosion resistant ground covers is indicated by these data to be every other year, especially when sideoats grama, switchgrass and bermuda are present.
2. Those recommendations on pages x and xi of the Final Report of Oklahoma Project No. 63-03-3, Roadside Development and Erosion Control, Part II on "Maintenance of Vegetative Ground Covers on Oklahoma Highways" are cited and supported by these data.

2. Grasses

a. East of US-81 and West of US-81

1. Those recommendations on page xii of the Final Report of Oklahoma Project No. 63-03-3, Roadside Development and Erosion Control, Part II on "Maintenance of Vegetative Ground Covers on Oklahoma Highways" are cited and supported by these data.

3. Maintenance and Weed Control

- a. Those recommendations on pages vii, xi and xii respectively of the Final Report of Oklahoma Project No. 63-03-3, Roadside Development and Erosion Control, Part II on "Maintenance of Vegetative Ground Covers on Oklahoma Highways" are cited and endorsed.

PART III

WEED CONTROL AND ERADICATION

1. SOIL STERILIZATION

- a. The herbicide prometone has exhibited good persistence and effectiveness in the control of bermudagrass and should be considered for use as a soil sterilant in the maintenance program on Oklahoma highways if economically feasible.
- b. Those recommendations given on pages viii through xiii of the Final Report of Oklahoma Project No. 63-03-3, Roadside Development and Erosion Control, Part III on "Weed Control and Eradication on Oklahoma Highways" are cited and supported by these data.

PART I

CAUSES AND CONTROL OF SOIL EROSION

ON

OKLAHOMA HIGHWAYS

INTRODUCTION

Roadside vegetation appropriately used protects the utility of a highway and adjacent lands, while its beauty provides the basis for scenic highways that are safer for the motoring public. Communication and close cooperation among engineers and agronomists in the design and development of the highway systems results in economical and satisfactory means of erosion control, better highways, and scenic beauty.

Many factors are responsible for soil erosion on the highway system. Some are more universal than others, but each contributes to the total cost for control. The principal causes of soil erosion are wind, water, and man. It is when man steps in and alters the balance of nature that erosion becomes more destructive and expensive to maintain.

PREVIOUS FINDINGS AND RECOMMENDATIONS^{1/}

A. Causes of Soil Erosion on Oklahoma Highways

The major causes of soil erosion on all areas of the Oklahoma highway system, especially on cut and fill slopes, generally were found to be

^{1/}Huffine, Wayne W., Lester W. Reed and Gary W. Roach. 1968. Causes and Control of Soil Erosion on Oklahoma Highways. Final Report, Oklahoma Project 63-03-3, Roadside Development and Erosion Control. Oklahoma State University.

improper design, improper maintenance, or both. The factors responsible for failures in plant establishment, or to persist after successful establishment generally were found to be as follows:

1. The use of weedy, low-grade vegetative mulch. On newly seeded cut and fill slopes the vegetative (hay) mulch frequently was composed largely of annual grasses and weeds, or was so heavily contaminated with seeds of these rapidly growing, undesirable plants that the slower growing, seeded perennials died or failed to become successfully established because of the competition for moisture, nutrients, and space.
2. Improper use of maintenance equipment. The operation of maintenance equipment mowers particularly, on highly erosive cut and fill slopes is the most destructive force currently acting upon the erosion control vegetative ground cover. The protective vegetative cover is not only destroyed by the improper practice of mowing too short and too frequently, but also by being physically torn from the soil by the shearing action of the tractor sliding as it attempts to traverse the slope generally in a horizontal direction, or from the spinning wheels in ascending the steep slopes, or as they slide in an attempt to stop or turn as they descend.

The "blading-off" of established vegetative ground cover especially native grasses on the highway shoulders, or the removal of soil from the top or slopes of stabilized cuts for repairs on fill slopes adds greatly to the problem and the cost of erosion control in the highway system.

3. Decline in soil fertility. Failure to provide maintenance levels of fertilizer to well established bermuda, weeping love

or native grass covers has led to a thinning or complete destruction of the vegetative cover resulting in certain soil erosion and costly repairs.

4. Improper highway design. Failure to acquire adequate rights-of-way for the construction of interceptor ditches on the top of cut slopes particularly, to facilitate the orderly removal of excess water has resulted in serious erosion from water pouring down the slope from terrace outlets or watershed above.

Previously, many backslopes were designed with a 3:1 slope, and some cases even 2:1 which created a droughty, difficult condition first for the establishment of the erosion control vegetative ground cover, and second for the maintenance over a period of time.

The lack of a physical barrier along the outer side of the shoulder from near the crest of a slope to the bottom for the purpose of concentrating and removing excess water in an orderly fashion has resulted in excessive erosion of fill slopes.

5. Injury to germinating seeds from high rates of starter fertilizer. Previously 400 pounds of 13-13-13 was applied per acre at the time of seeding. This amount was found to be injurious to germinating seeds of the desired grasses.

B. Recommendations for Erosion Control on Oklahoma Highways

To provide more satisfactory and economical methods for the prevention and control of soil erosion on Oklahoma highways the following recommendations were made based upon findings in the initial investigations:

1. Weeping lovegrass seems to be more widely adapted and easier to establish for erosion control than other species tested and its

use throughout the State is to be encouraged until such time a more satisfactory grass becomes available.

2. The use of high-grade hay or excelsior for vegetative mulch is strongly recommended. No more than a trace of weeds (preferably none) with mature seeds should be present in the vegetative mulch. Low-grade vegetative mulch composed of undesirable weedy annuals, or perennial johnsongrass should be avoided without exception.
3. Apply no more starter fertilizer than 200 pounds of 13-13-13 per acre at the time of seeding for optimum germination and establishment of the desired grasses.
4. Flatten backslopes and fills as much as possible. Avoid slopes steeper than 3:1 if possible where a vegetative ground cover is to be used for erosion control. If 2:1 backslopes must be designed as on urban roadways particularly, plans for permanent supplemental irrigation should be prepared initially.
5. Provide for interceptor ditches at the top of cut slopes particularly, and on the berms of deep cuts, to facilitate the collection and orderly removal of excess water that pours down from terrace outlets or watersheds above, or that falls on the slope itself.
6. Utilize a physical barrier along the outer side of the shoulder on long slopes particularly, and on the inside of curves for the purpose of concentrating and removing excess water in an orderly fashion.

RESEARCH
ON THE
CONTROL OF SOIL EROSION ON OKLAHOMA HIGHWAYS

The principal objectives of this phase of the research project were to find satisfactory and economical methods for the prevention and control of soil erosion along Oklahoma highways. To achieve these objectives several factors were to be evaluated. The principal factors involved in erosion control are plant species, soils and soil fertility, slope and exposure, and cultural practices best suited for the establishment and maintenance of permanent vegetation.

The results presented in this report are supplemental to and in support of the research described in the Final Report, Part I, of the Oklahoma Project No. 63-03-3 on Roadside Development and Erosion Control prepared in 1968 dealing with "Causes and Control of Soil Erosion on Oklahoma Highways."

FINDINGS AND CONCLUSIONS

Grasses are generally recognized for most situations to be the most practical roadside cover as they combine good erosion control with an attractive appearance. Although easier to establish and maintain than most plants used for erosion control grasses vary in their ability to germinate and grow under different soil and climatic conditions.

Plants that are known to be well adapted to a particular area under natural conditions may be completely unsuited to sites developed by man that creates an entirely different environment. A high fill or backslope with a north exposure creates an entirely different environment for plant growth than a similar site facing south. North exposures at this latitude tend to be cooler in summer and much colder in winter than those that face south.

Too, the intensity and amount of direct sunlight is less on north exposures which greatly influences plant growth and persistence. A west facing slope tends to be hotter, and drier in summer than one facing east.

The steepness of slope on cuts and fills tend to make these soils drier than those nearby. It is known dry soils permit faster and greater changes in temperature in a shorter period of time than soils that are moist. Therefore, the strong, cold winds of winter inflict the greatest damage to those susceptible plants on slopes that face north.

Weeping lovegrass (Eragrostis curvula Nees.) as pointed out in Part I of the Final Report, Oklahoma Project 63-03-3, is one of the most widely adapted, easily established grasses tested for the control of soil erosion on Oklahoma highways. Successful seedings have been made on sandy soils and clays, and on north facing slopes as well as those that faced south. Seedings made on highly erosive cut slopes in western Oklahoma near Elk City showed weeping lovegrass mulched with either asphalt or the wood cellulose fiber product Turfiber^{2/}, and KR bluestem (Bothriochloa ischaemum) mulched with Turfiber provided significantly more ground cover on a north facing slope for erosion control (Figure 1) than any other grasses tested. Across the highway, but on a south facing slope, weeping lovegrass mulched with asphalt provided significantly more ground cover for erosion control (Figure 2) than any other grasses or mulch tested. In this seeding KR bluestem mulched with either asphalt or Turfiber and weeping lovegrass mulched with Turfiber provided the same amount of ground cover but were significantly less than weeping lovegrass with asphalt. It should be pointed out that heavy rains from the south occurred the week after seeding and caused severe loss of soil, seed, and mulch which could account for some of the differences. This could be a good indication of the merits of weeping lovegrass mulched

^{2/}Product of International Paper Company.

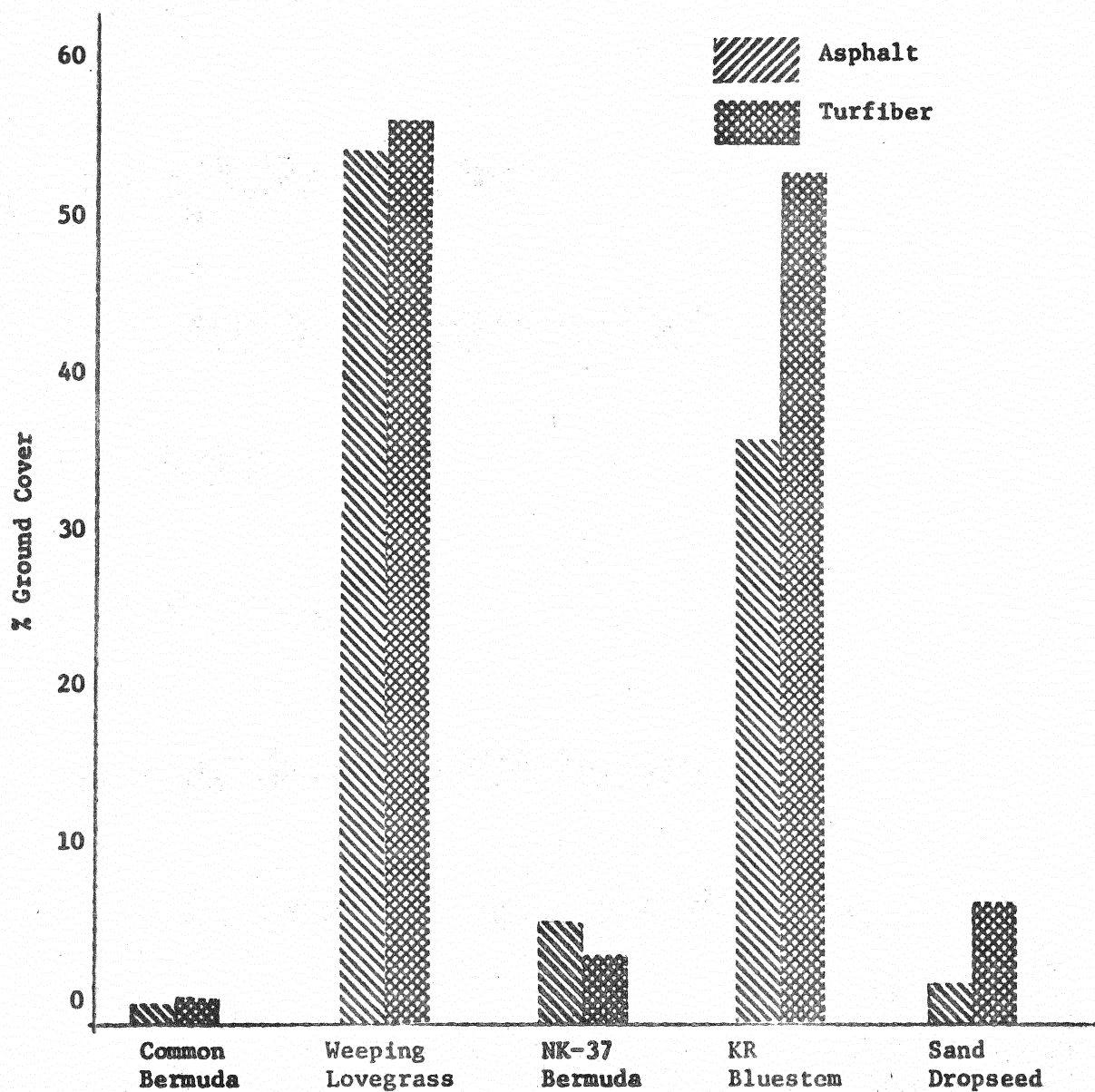


Figure 1. The evaluation of five grasses and two mulches for erosion control on a north facing cut slope seeded and mulched June 9, 1965, on SH-6 four miles west of US-66 intersection west of Elk City, Oklahoma. This area was fertilized with 200 lbs. 10-20-10 per acre on June 9, 1965, and again on March 17, 1966 and evaluated on September 2, 1968.

with asphalt for erosion control on highly erosive soils.

In north-central Oklahoma, east of Stillwater, bermudagrass (Cynodon dactylon (L.) Pers.) responded to the warmer temperatures on a south facing slope the year after seeding and provided slightly more protection from soil erosion than did weeping lovegrass. Two years after seeding, however, weeping lovegrass provided nearly 25% more ground cover than did the rapid growing giant-type bermudagrass (Figure 3), and approximately 70% more than common bermuda. These results would tend to indicate an advantage exists in the use of the rapid growing NK-37 variety for soil protection and erosion control when compared to the seeded common bermudagrass.

Across the highway from the above experiment an investigation into the effect of tillage on the germination and growth of bermuda and weeping lovegrass was made. The effect of a north exposure on bermudagrass was quite evident with a decline in plant population one year after seeding. The decline in percent ground cover by bermudagrass reached practically complete absence two years after seeding (Figure 4). Weeping lovegrass persisted and provided almost 60% ground cover. Tillage two years previously did not seem to improve the stand of weeping lovegrass. These results further support the earlier research findings and recommendation for the use of weeping lovegrass for erosion control on north facing slopes.

The production of a protective bermudagrass cover on a droughty, geological soil as found on a deep, west-facing backslope in central Oklahoma appears to be influenced more by fertilization than from tillage prior to seeding or the incorporation of lime (Figure 5). These data further emphasize the need for fertilization periodically wherever and whenever bermudagrass is used for erosion control on Oklahoma highways.

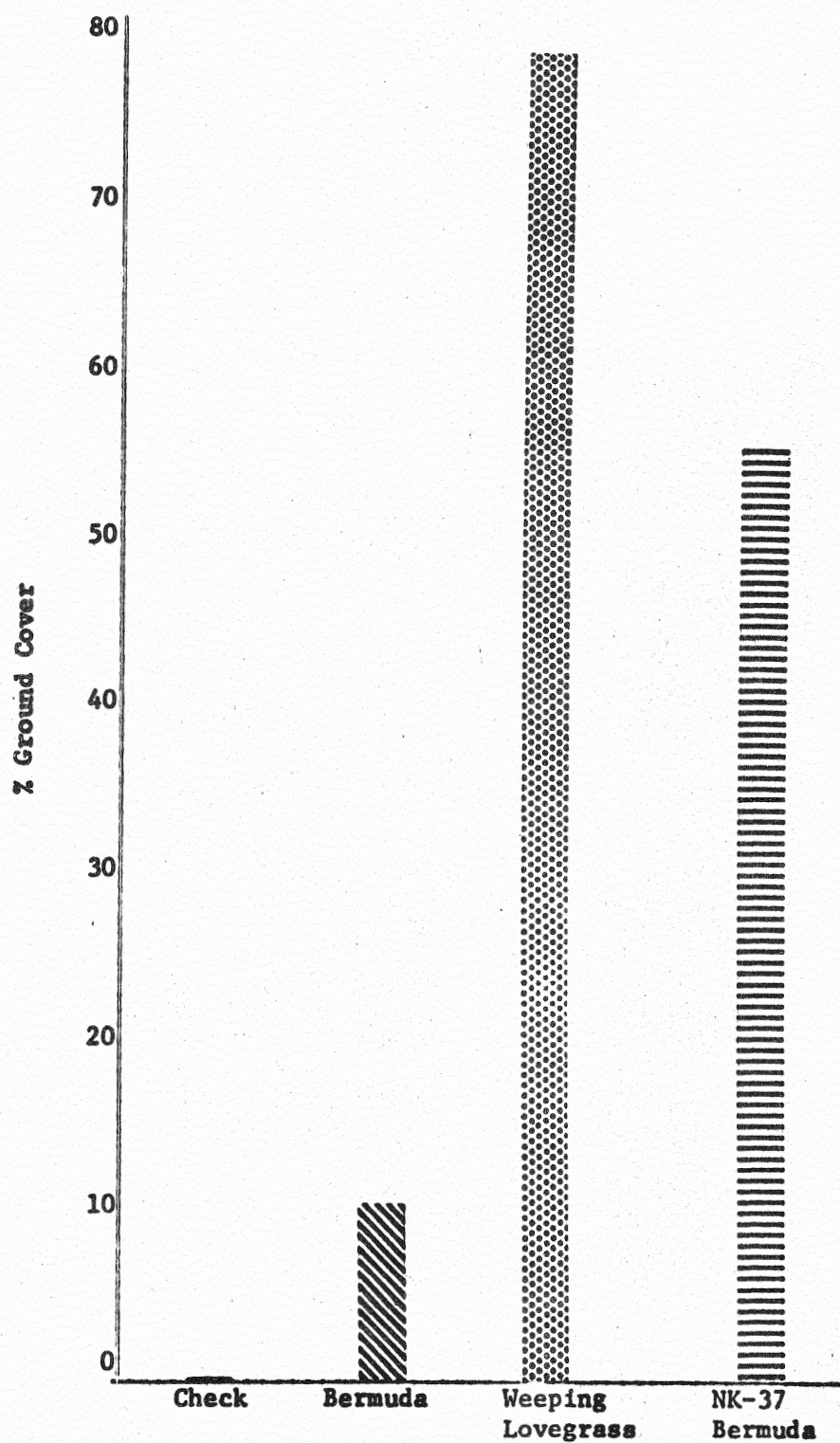


Figure 3. A comparison of three grasses for erosion control on a south facing cut slope east of Stillwater, Oklahoma, on SH-51 four miles east of SH-108 seeded and hay mulched May 4, 1966, and fertilized with 435 lbs./acre of 10-20-10 on May 23, 1967 as evaluated on September 6, 1968.

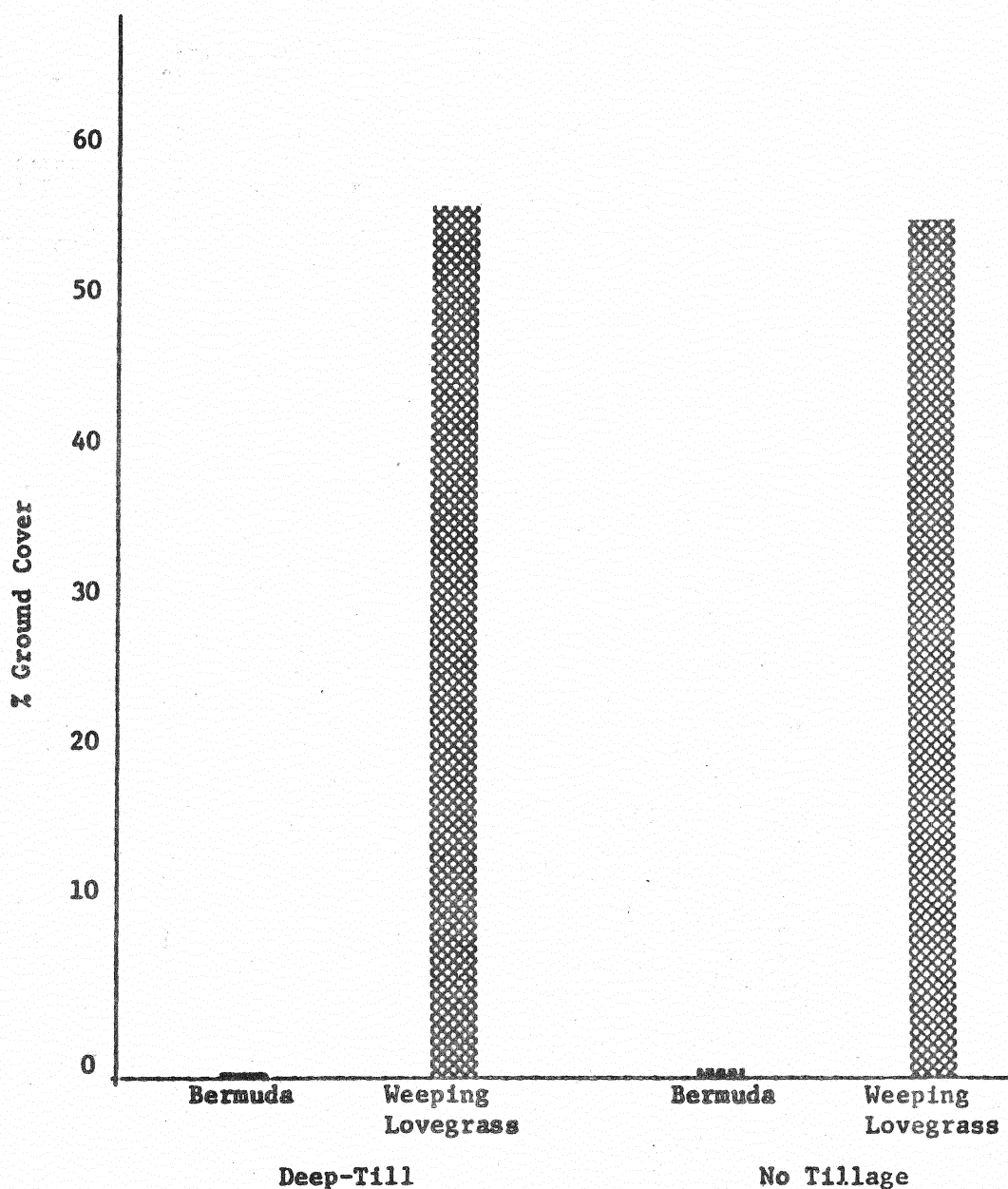


Figure 4. The effect of a deep-tillage operation on the establishment of bermudagrass and weeping lovegrass seeded and hay-mulched May 4, 1966, and fertilized with 435 lbs./acre of 10-20-10 May 23, 1967, on a north facing cut slope east of Stillwater, Oklahoma on SH-51 four miles east of SH-108 as evaluated on September 6, 1968.

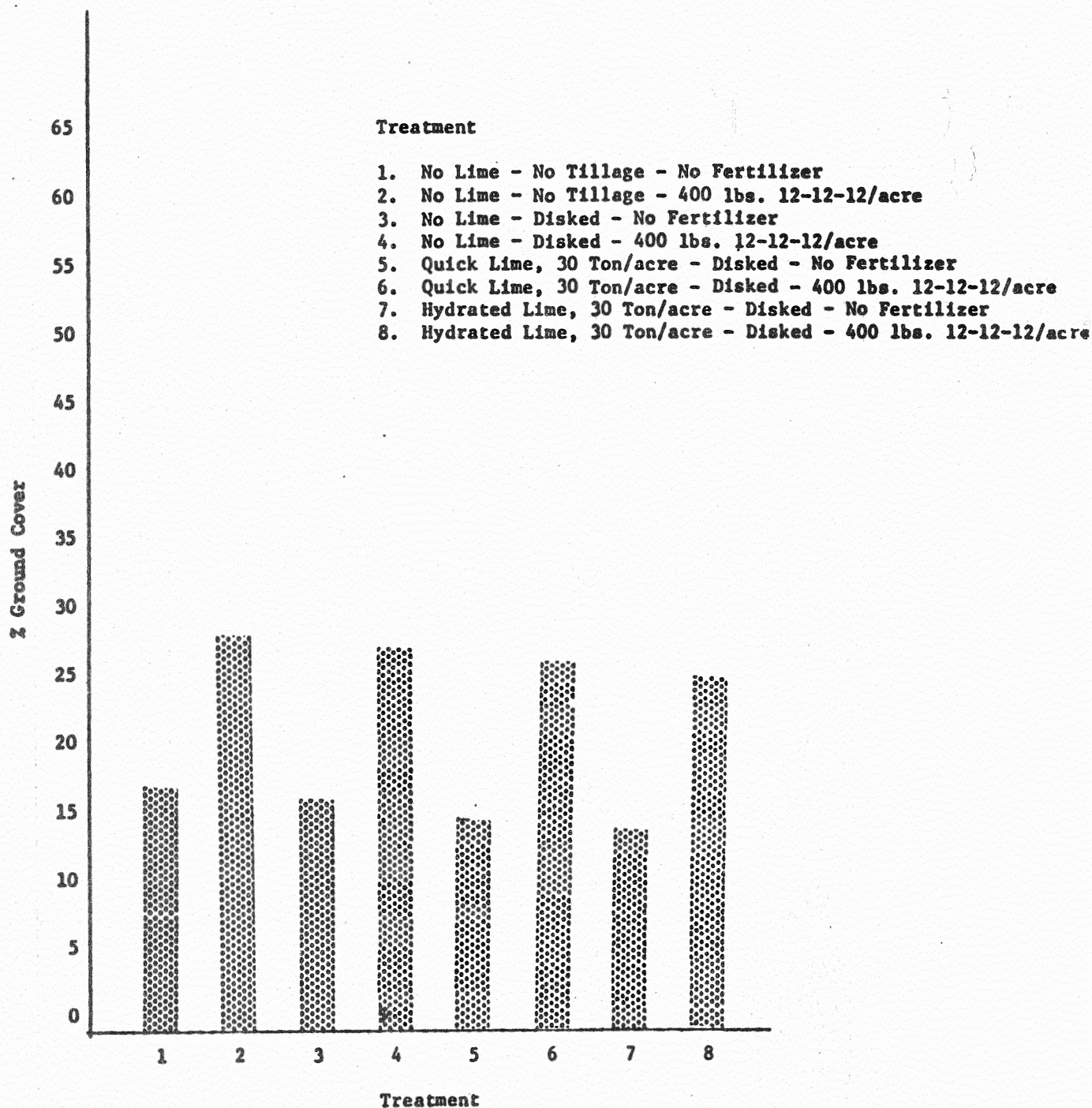


Figure 5. The effect of lime, fertilizer, and disking on the establishment of common bermudagrass on a west facing cut slope one mile north of SH-33 on I-35 east of Guthrie, Oklahoma. Lime was applied June 18, 1964, the area seeded February 3, 1965, and fertilized June 24, 1965, with 400 lbs. of 12-12-12 per acre. Evaluated November 1, 1968.

PART II
MAINTENANCE OF VEGETATIVE GROUND COVERS
ON
OKLAHOMA HIGHWAYS

INTRODUCTION

There are more than 12,000 miles of roads and highways in Oklahoma that must be maintained each year and more are being constructed. Statistical records indicate approximately \$3 to \$4 million dollars were spent annually in the fiscal years 1963-1967 for erosion control. Historically, excessively heavy applications of fertilizer have been made in the initial erosion control program, but none or at most only a token amount on a few select sites was provided for maintenance regardless of need.

PREVIOUS FINDINGS AND RECOMMENDATIONS^{3/}

A. Factors Responsible for the Loss of Established Ground Covers

The lack of proper maintenance was found to be the most common reason for the loss of established ground covers. It was recognized also that the direction of exposure, degree of slope, and choice of plant species contributed to the unquestionable decline and ultimate loss of some vegetative covers. The factors most commonly involved in the loss of established ground covers were found to be as follows:

1. The lack of maintenance applications of fertilizer.
2. Improper mowing.
3. "Blading-Off" established vegetative ground cover.
4. Lack of research information on plant adaptation to man-made sites.

^{3/}Huffine, Wayne W., Lester W. Reed and Gary W. Roach. 1968. Maintenance of Vegetative Ground Covers on Oklahoma Highways. Final Report, Oklahoma Project 63-03-3, Roadside Development and Erosion Control. Oklahoma State University.

B. Recommendations for Maintenance of Vegetative Ground Covers on Oklahoma Highways.

To provide economical and satisfactory methods to maintain a good vegetative ground cover after its successful establishment, and to restore a protective plant cover on areas where the vegetation diminished with a decline in soil fertility the following recommendations were made based upon findings in the initial investigations:

1. Mowing--a. DO NOT MOW CUT AND FILL SLOPES

- b. Areas other than slopes that must be mowed, should not be clipped lower than 4 to 6 inches above the soil surface, and no more frequently than 60 day intervals.

2. Grading--a. DO NOT "BLADE-OFF" ESTABLISHED VEGETATIVE GROUND COVER FROM THE HIGHWAY SHOULDERS, ESPECIALLY THE NATIVE TALLGRASSES.

- b. DO NOT BORROW SOIL FROM THE TOP OR SLOPES OF STABILIZED CUTS.

3. Fertilization

a. East of US-81

1. General for ALL GRASS MIXTURES ON ALL SLOPES.

Apply 100-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 or 3 years.

2. Predominately WEEPING LOVEGRASS COVERED SLOPES.

Apply 50-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application nce every 2 to 3 years.

3. Predominately BERMUDAGRASS COVERED SLOPES.

Apply 100-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 to 3 years.

4. Predominately BERMUDAGRASS COVERED SHOULDERS

and ALL LEVEL AREAS. Apply 100-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 to 3 years.

5. SWITCHGRASS in a vegetative mixture responds to

an application of 50-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 to 3 years.

6. KR BLUESTEM in a vegetative mixture has indicated no response to supplemental fertilization, therefore, none is recommended.

b. West of US-81

1. General for ALL GRASS MIXTURES ON ALL SLOPES.

Apply 100 pounds of actual nitrogen per acre per application once every 2 to 3 years.

2. Predominately WEEPING LOVEGRASS COVERED SLOPES.

Apply 100-34-0 pounds of actual nitrogen, and phosphorus respectively per acre per application once every 2 to 3 years.

3. Predominately BERMUDAGRASS COVERED SLOPES.

Apply 100-34-0 pounds of actual nitrogen, and phosphorus respectively per acre, per application once every 2 to 3 years.

4. SIDEOATS GRAMA in a vegetative mixture responds to an application of 100-17-16 pounds of actual nitrogen, phosphorus, and potassium respectively per acre per application once every 2 to 3 years.
5. BUFFALOGRASS in a vegetative mixture responds to an application of 100 pounds of actual nitrogen per acre per application once every 2 to 3 years.
6. SWITCHGRASS in a vegetative mixture responds to an application of 50 pounds of actual nitrogen per acre per application once every 2 to 3 years.

4. Weed Control

a. All of Oklahoma

The application of a post-emergence herbicide for broadleaf weed control, such as dicamba (Banvel-D*) at the rate of 1 pound of active ingredient per acre following the first application and perhaps subsequent ones of fertilizer would permit more efficient use of plant nutrients by the desired grasses.

5. Grasses

a. East of US-81

1. WEEPING LOVEGRASS is better adapted for use on all slopes than any other grass tested.
2. BERMUDAGRASS is better adapted for use on south facing slopes than any other grass tested.

*Tradename of Velsical Chemical Corporation.

3. WEEPING LOVEGRASS is better adapted for use on north facing slopes than any other grass tested.
4. BERMUDAGRASS is better adapted for use on east or west facing slopes than any other grass tested.

b. West of US-81

1. SIDEOATS GRAMA is better adapted for use on all slopes than any other grass tested.
2. WEEPING LOVEGRASS is equally well adapted as sideoats grama for use on south facing slopes.
3. SWITCHGRASS is equally well adapted as sideoats grama generally east of the panhandle for use on north facing slopes.
4. BUFFALOGRASS is better adapted for use on east or west facing slopes of all the grasses tested.
5. BERMUDAGRASS is better adapted for use on all except north facing fill slopes of all the grasses tested.

RESEARCH
ON THE
FERTILITY REQUIREMENTS FOR IMPROVEMENT
AND MAINTENANCE OF VEGETATIVE GROUND COVERS

The principal objectives of this part of the research project were to find satisfactory and economical methods to maintain a good vegetative ground cover after its successful establishment, and to restore a protective plant cover on areas where turf failure has occurred principally from a decline in soil fertility. To achieve these objectives several factors were to be evaluated. The major items of concern were:

1. The influence of design on the successful and economical establishment and maintenance of vegetative ground covers on cut and fill slopes.
2. The establishment of fertility requirements for maintenance of vegetatively stabilized slopes.
3. The effect of plant competition on maintenance of the desired vegetation.

The results presented in this report are supplemental to and in support of the research described in the Final Report, Part II, of the Oklahoma Project NO. 63-03-3 on Roadside Development and Erosion Control prepared in 1968 dealing with "Maintenance of Vegetative Ground Covers on Oklahoma Highways".

FINDINGS AND CONCLUSIONS

Properly used, fertilizer enables established grasses to enhance the beauty of the landscape and effectively protect the soil surface from erosion. The restoration of a protective vegetative cover on the soil surface

is possible with applications of fertilizer at frequent intervals based upon soil tests.

Although plant response to fertilizer is generally rapid on low fertility soils, the determination of the most effective and economical treatments is slow because of the numerous variables involved. Weather is one of the most influential of these variables in field studies.

An excavation area of raw shale and sand located on US-69 near Eufaula, was seeded initially in May 1965 with bermudagrass, buffalograss and little hop clover (Trifolium dubium) and mulched with weeping lovegrass hay. The area was fertilized at the time of seeding with 200 pounds 12-12-12 per acre, and topdressed with 100 pounds of ammonium nitrate per acre in September 1965. In April 1966 three levels of gypsum were applied followed by four levels of nitrogen-phosphorus fertilizers applied in late May 1966. The next month a post-emergence herbicide was applied for broadleaf weed control. A fair stand of bermuda with traces of lovegrass and buffalo were present initially. The responses from the grasses to these treatments in the first two years showed a highly significant increase in the bermudagrass cover from nitrogen fertilization. No real response to phosphorus fertilization, gypsum, or herbicide treatment could be demonstrated initially but later there were definite indications of significant increases in the percent ground cover of bermuda and weeping lovegrass from a combination nitrogen-phosphorus fertilization and gypsum treatments.

Three years after fertilization no significant differences could be found in the percent ground cover among treatments as shown in Figures 6 through 17 in the investigation at Eufaula. These results tend to support the previous recommendations for periodic applications of fertilizer once every 2 to 3 years. Since there were no real differences in percent ground cover even from those plots that received the largest amounts of fertilizer

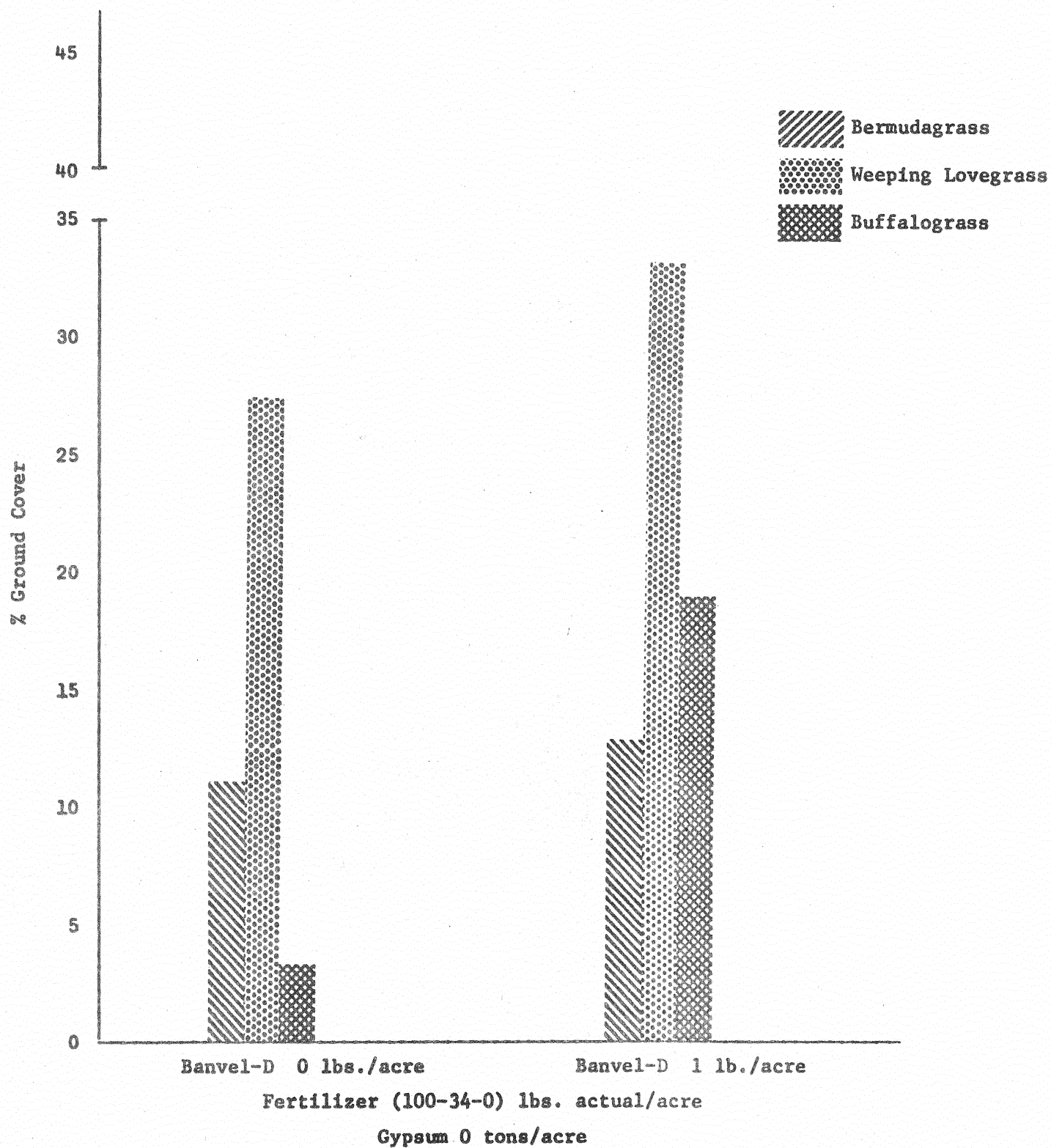


Figure 6. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

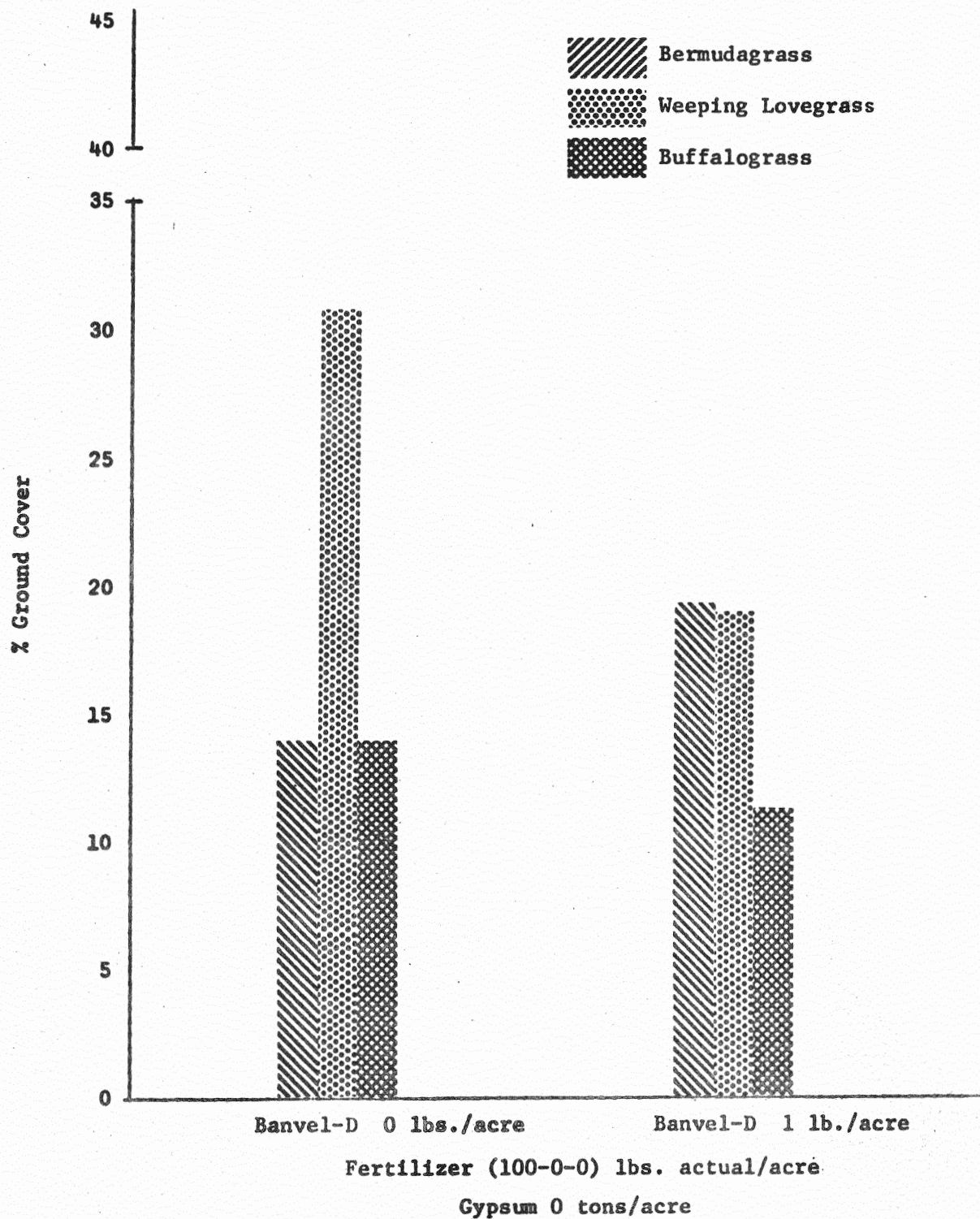


Figure 7. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

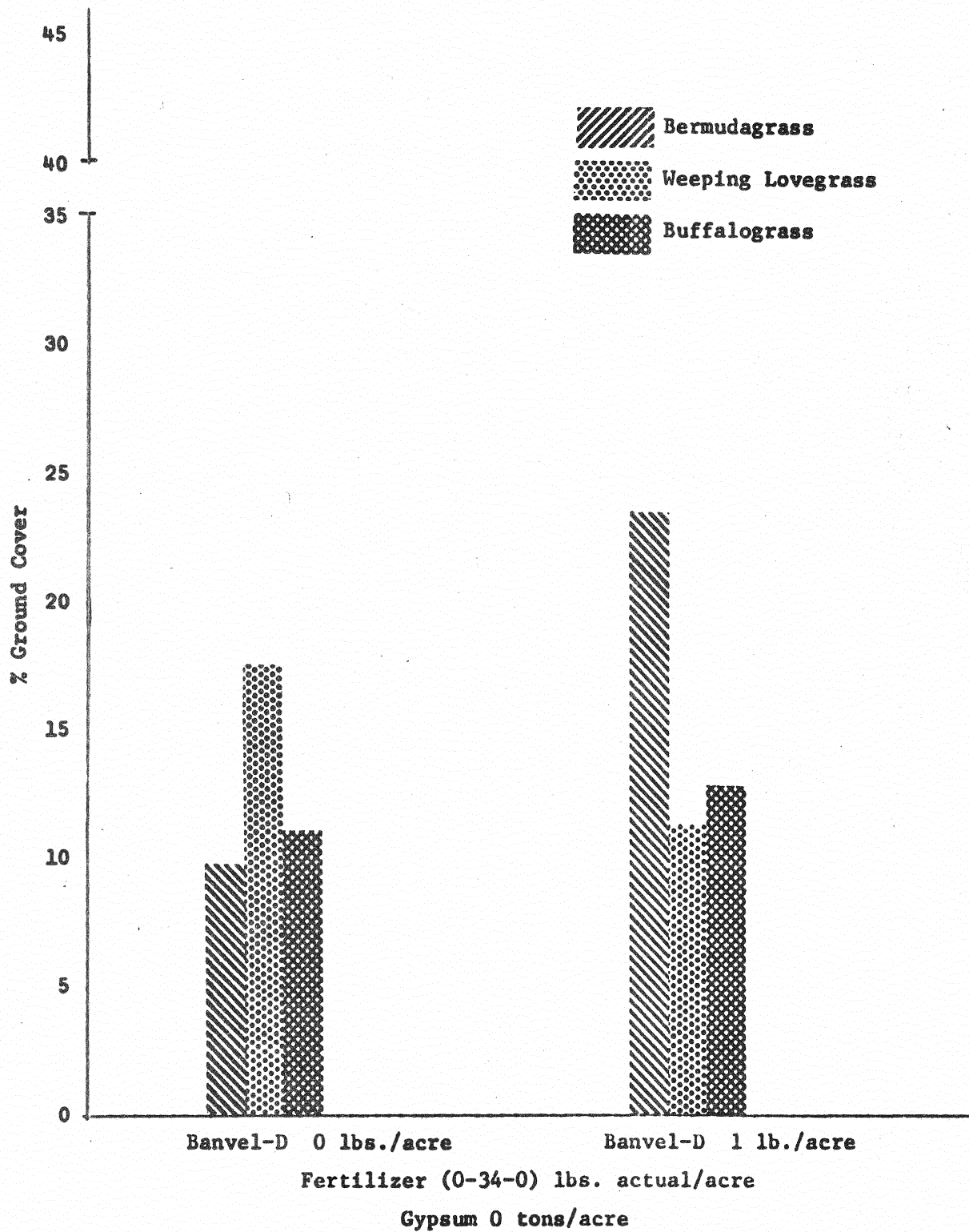


Figure 8. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

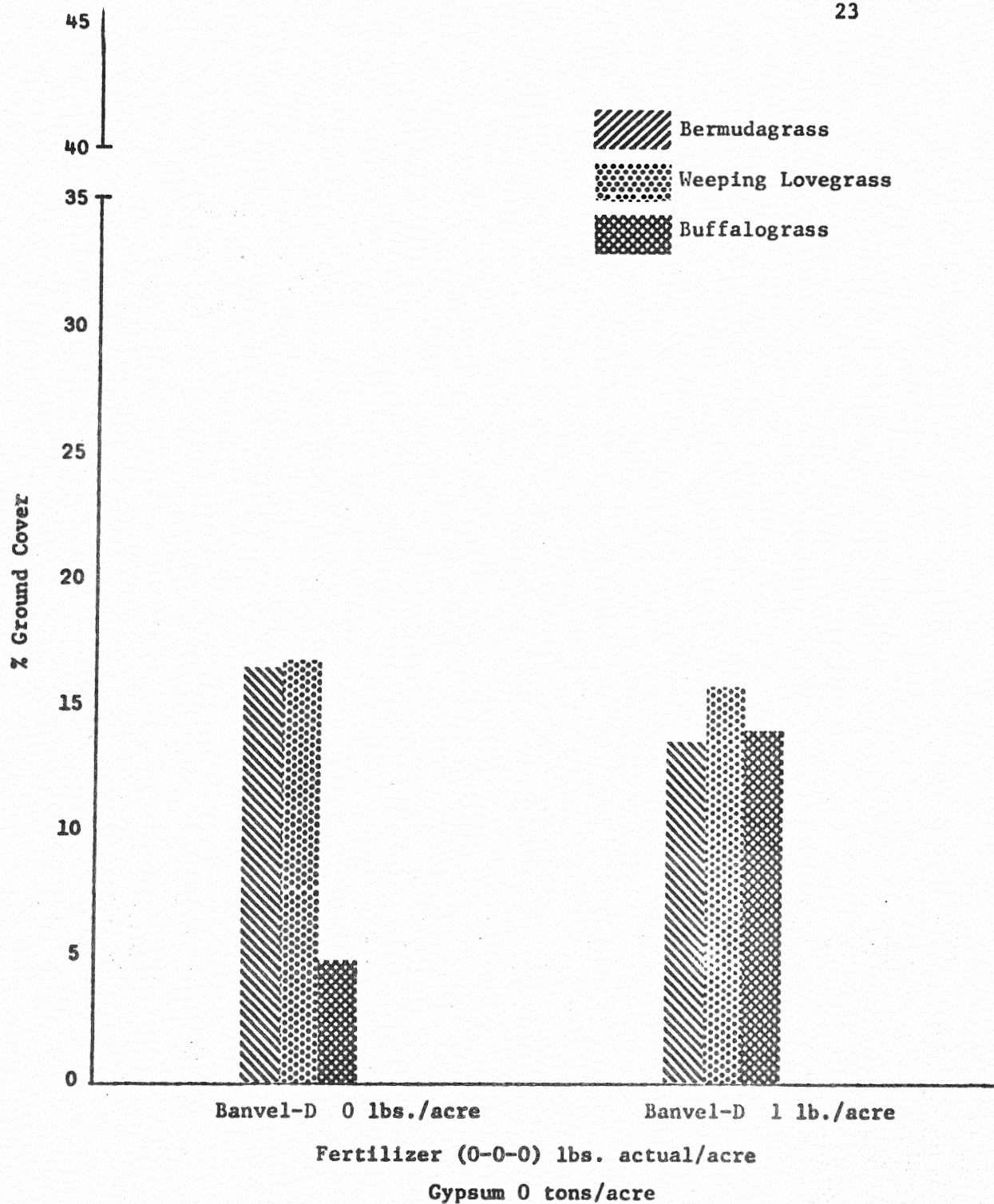


Figure 9. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

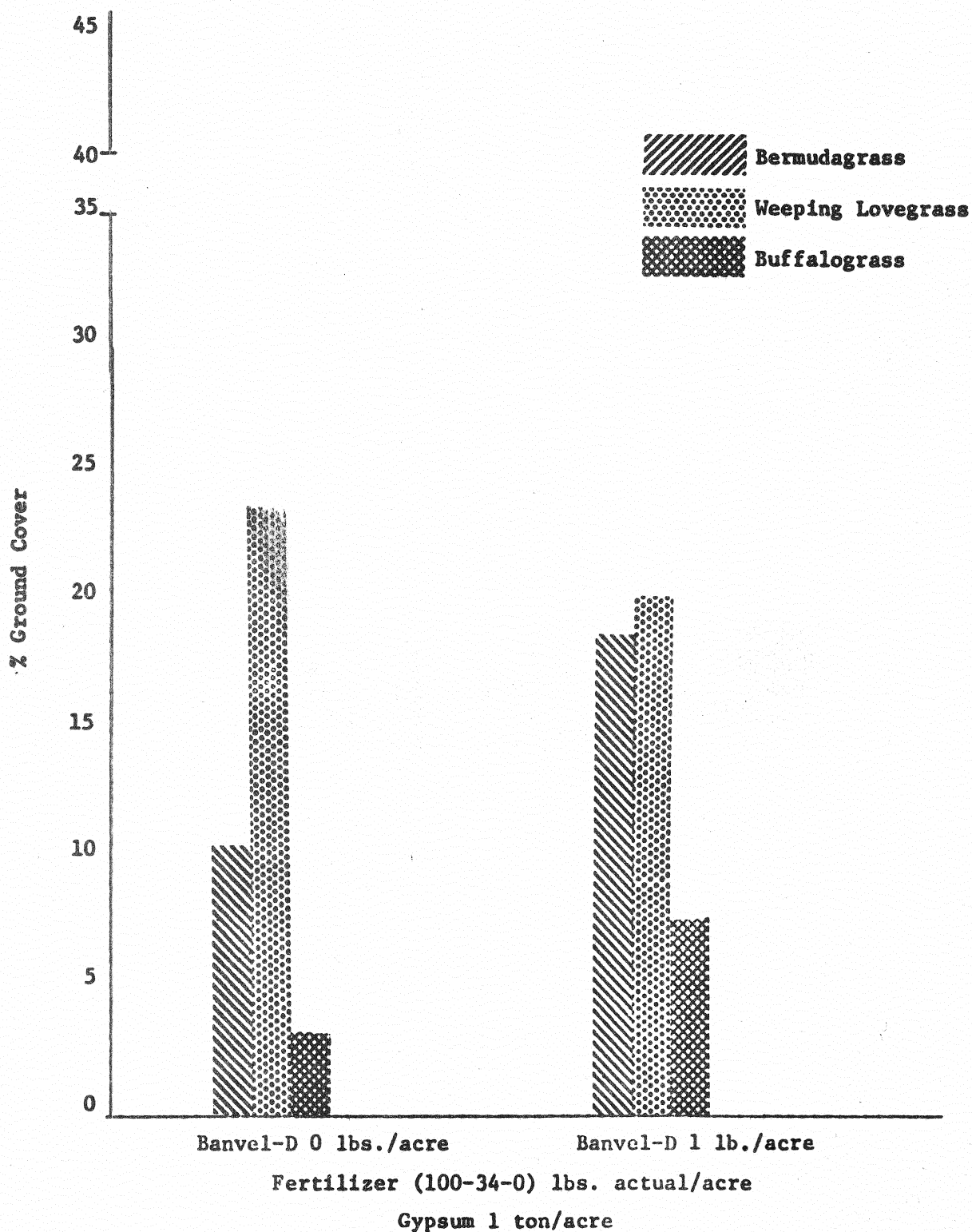


Figure 10. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

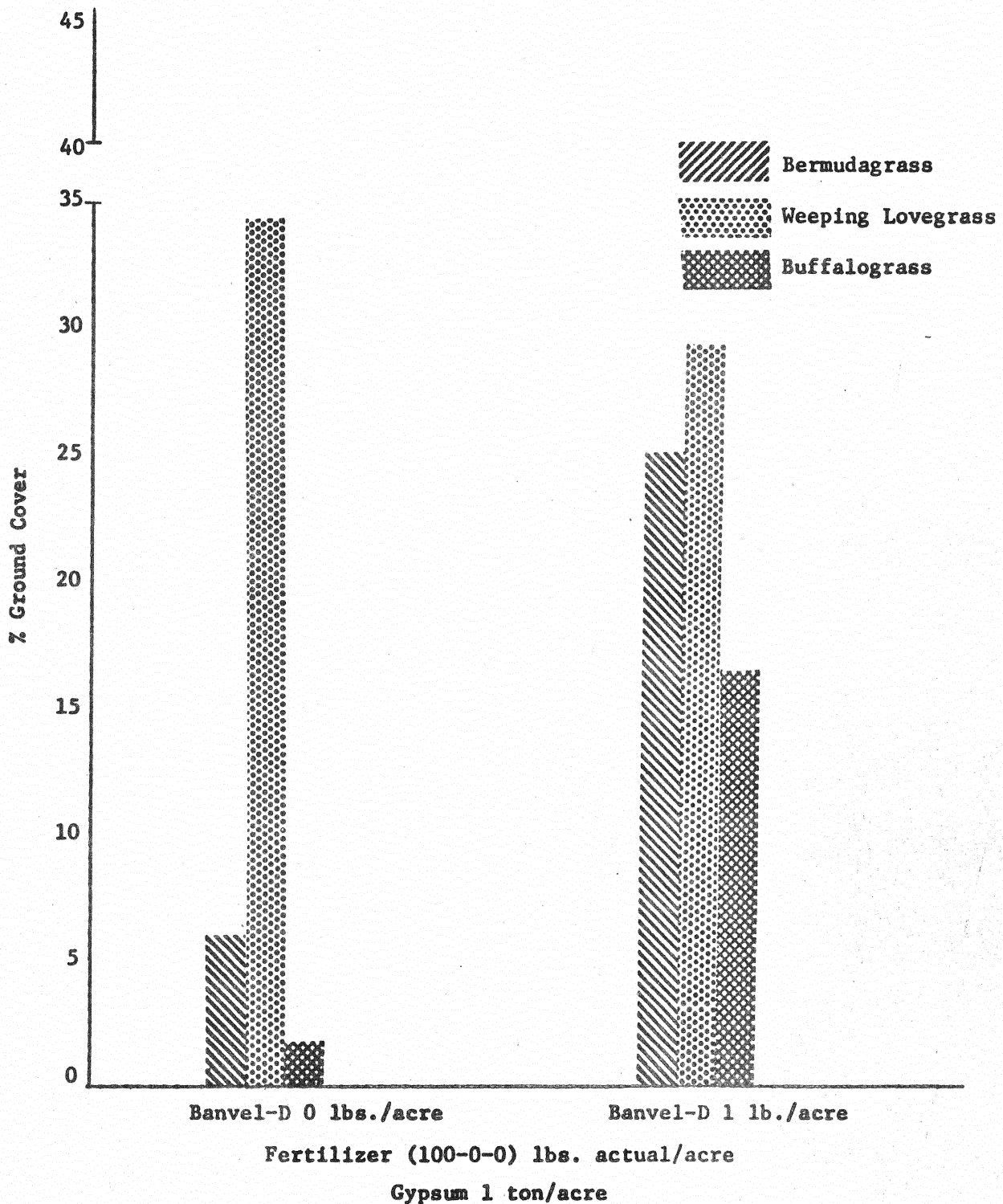


Figure 11. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

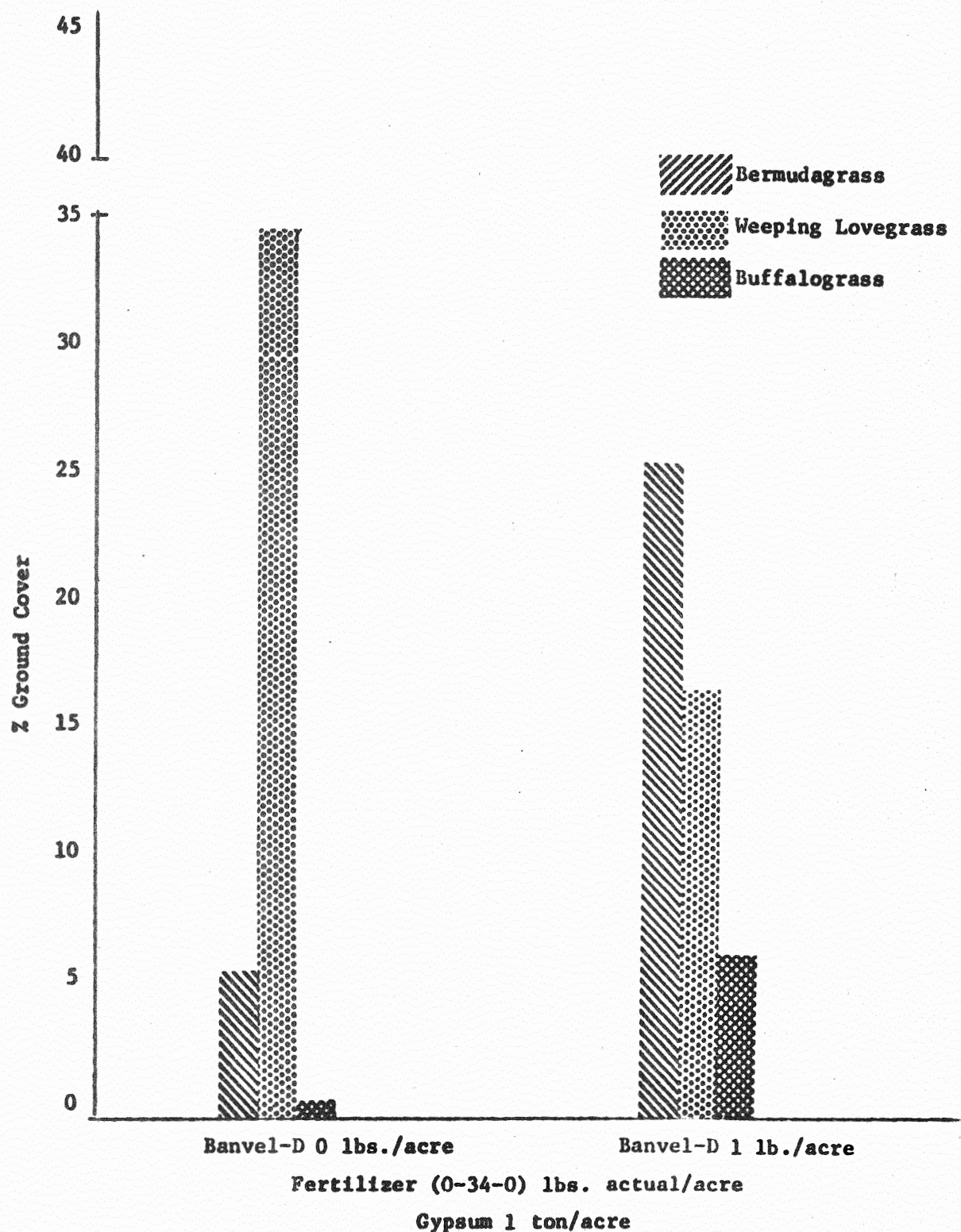


Figure 12. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

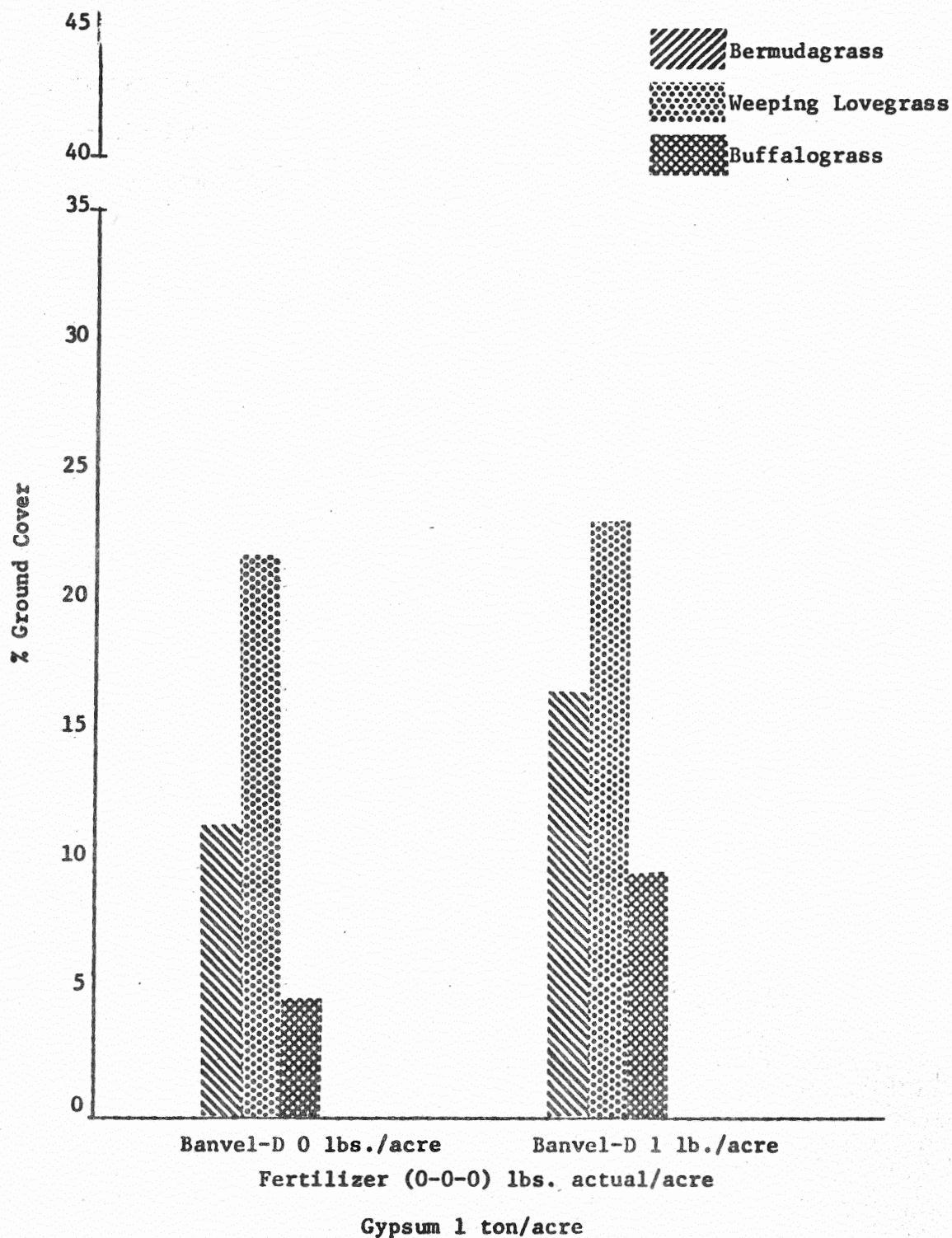


Figure 13. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

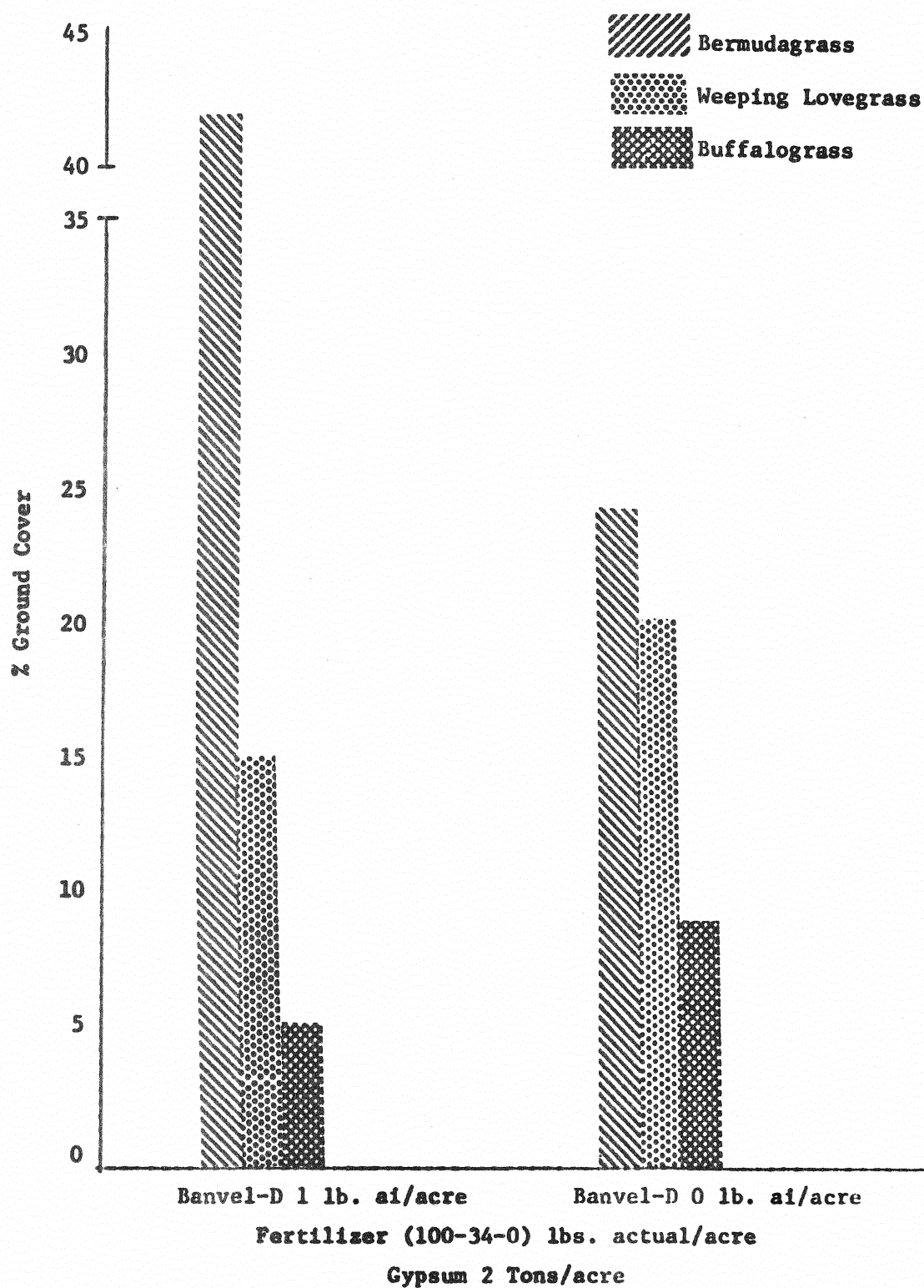


Figure 14. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

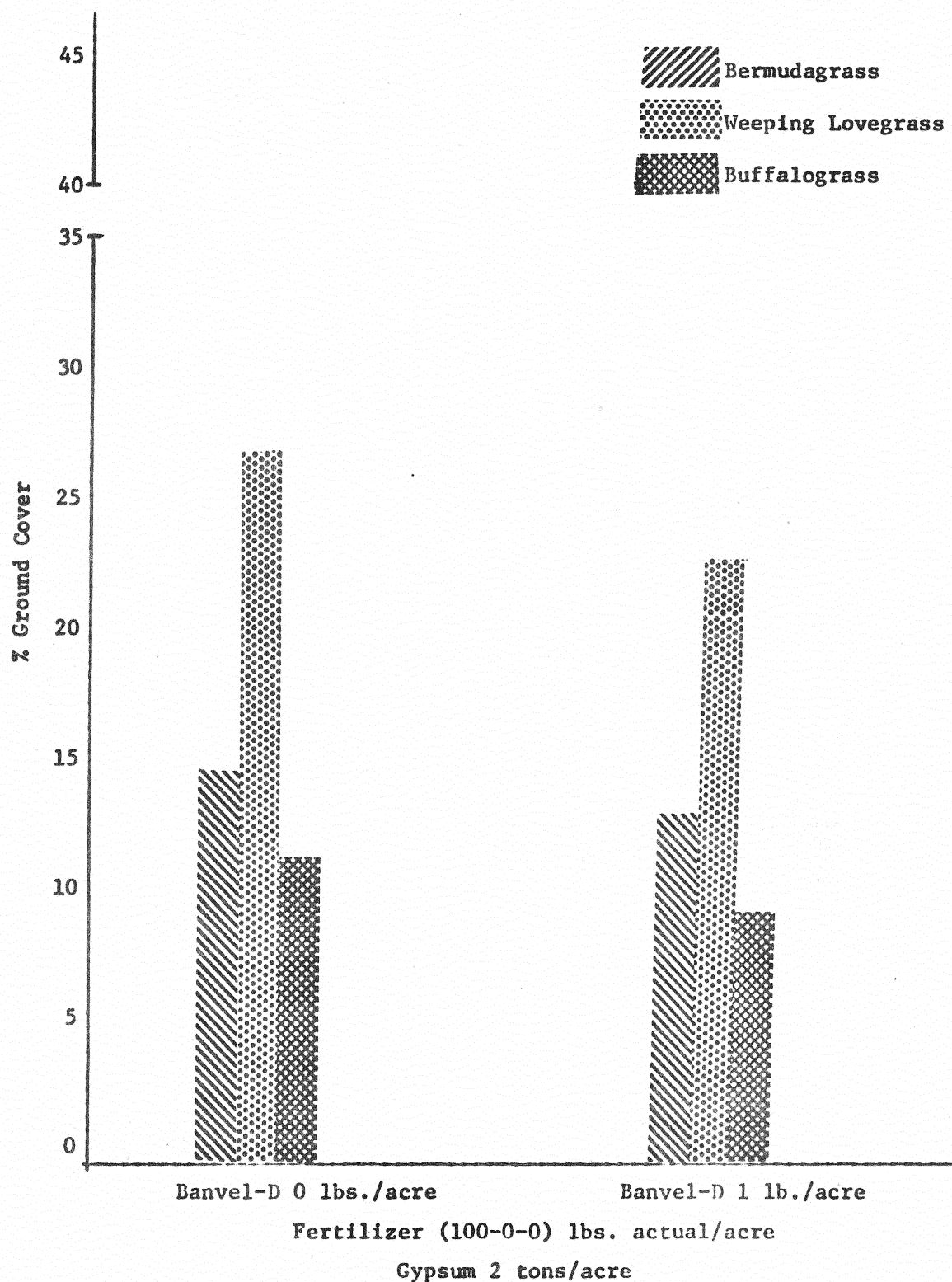


Figure 15. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

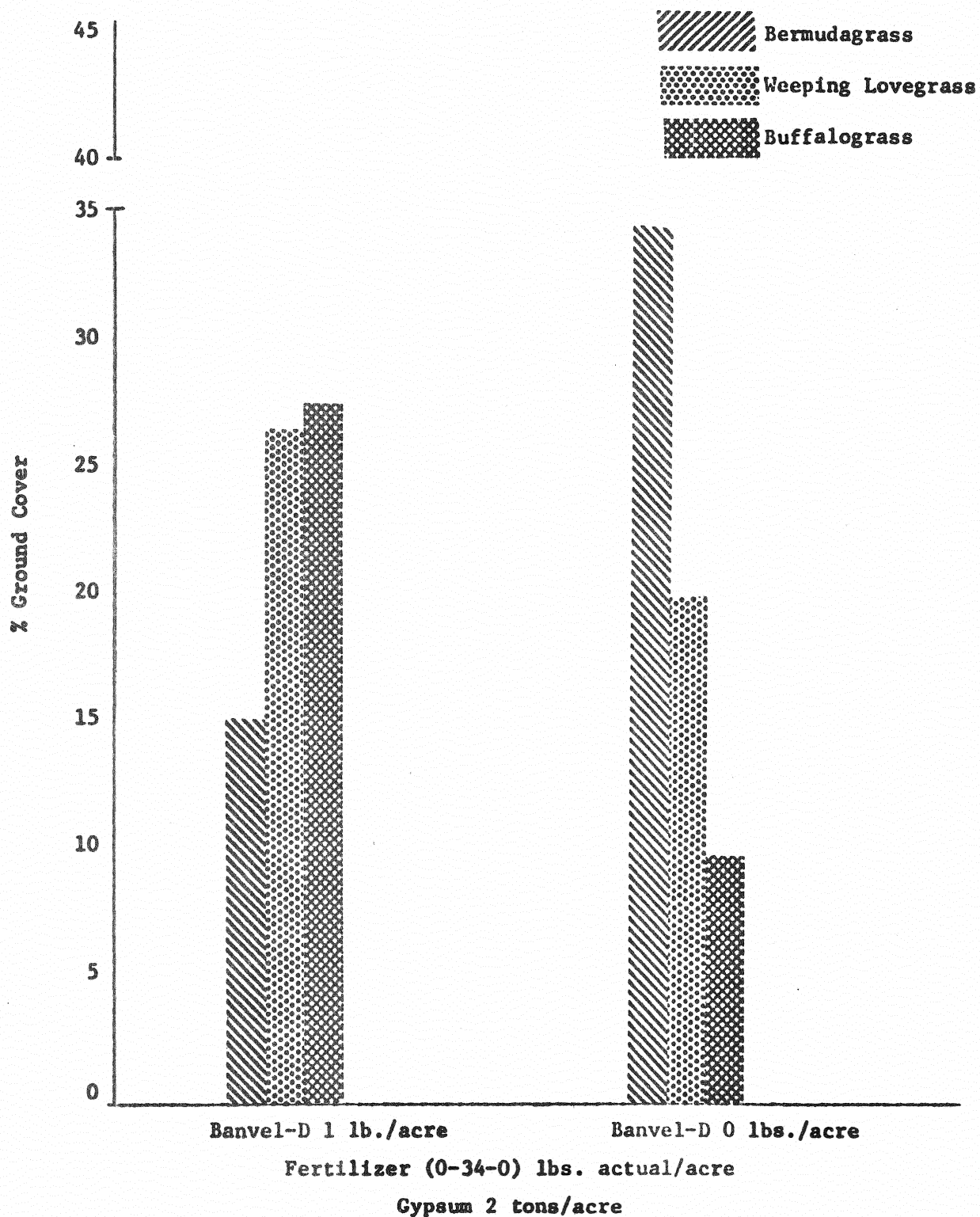


Figure 16. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

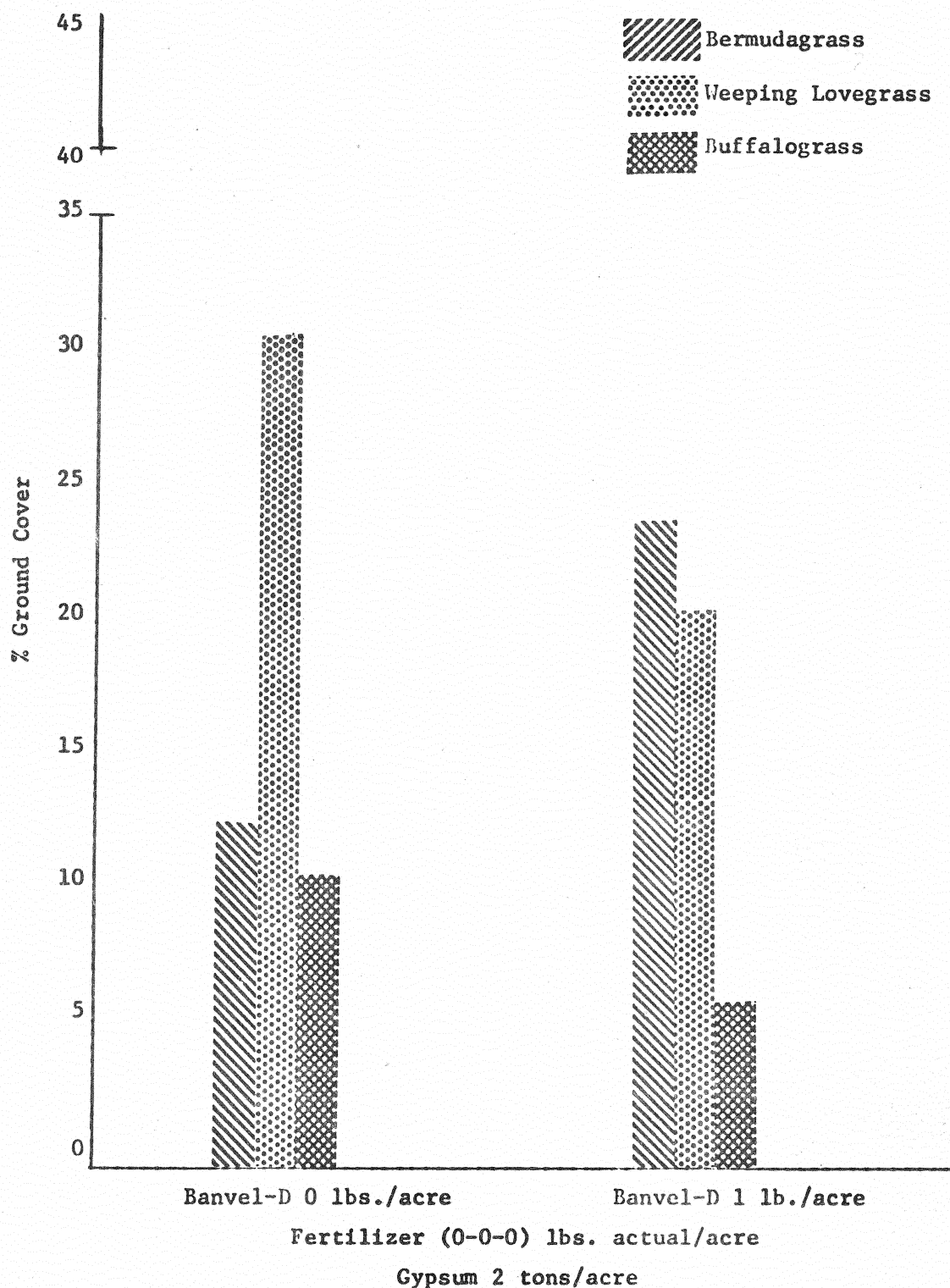


Figure 17. The effect of four rates of fertilizer, three rates of gypsum, and one rate of Banvel-D herbicide on the growth of three grasses on US-69 north of Eufaula, Oklahoma, at the junction of US-69 Business Route as evaluated November 20, 1968.

initially, this tends to indicate a rather rapid loss or depletion of plant nutrients on soils of this type in eastern Oklahoma, and a need for frequent (perhaps light) applications of fertilizer.

The effects of fertilizer applied in alternate years of 1964 and 1966 diminished to the point of no significant differences two years later as indicated by the percent ground cover by treatments in the experiment located on a south facing slope on US-270 near Holdenville as shown in Figures 18 and 19. One noticeable change in species composition is evident with the increase in KR bluestem to the place where it is dominant in all cases with the one exception of the high level of fertilizer treatment where bermudagrass provides a slightly greater amount of ground cover. As was reported previously in the Final Report of Oklahoma Project 63-03-3, Part II, page ix, KR bluestem indicated no response to supplemental fertilization for erosion control. If these data can be substantiated with additional research it would mean a significant savings in maintenance costs could be effected by having KR bluestem as a part of the grass mixture for erosion control.

In a duplicate experiment (with the exception of a north exposure) just across the highway (US-270) south from the above described study weeping lovegrass is the dominant vegetation, with KR bluestem a poor second and bermudagrass practically gone as shown in Figures 20 and 21. This supports the statement on page xii of the Final Report of Oklahoma Project 63-03-3, Part II, that east of US-81 highway weeping lovegrass is better adapted for use on north facing slopes than any other grass tested. The effects of the fertilizer treatments have diminished to the point that no significant differences could be measured. However, KR bluestem has increased about 20 to 25 percent in ground cover when fertilized with 50 to 100 pounds of nitrogen per acre in each of three consecutive years as compared to an approximate 7% decrease for the same period of time when unfertilized.

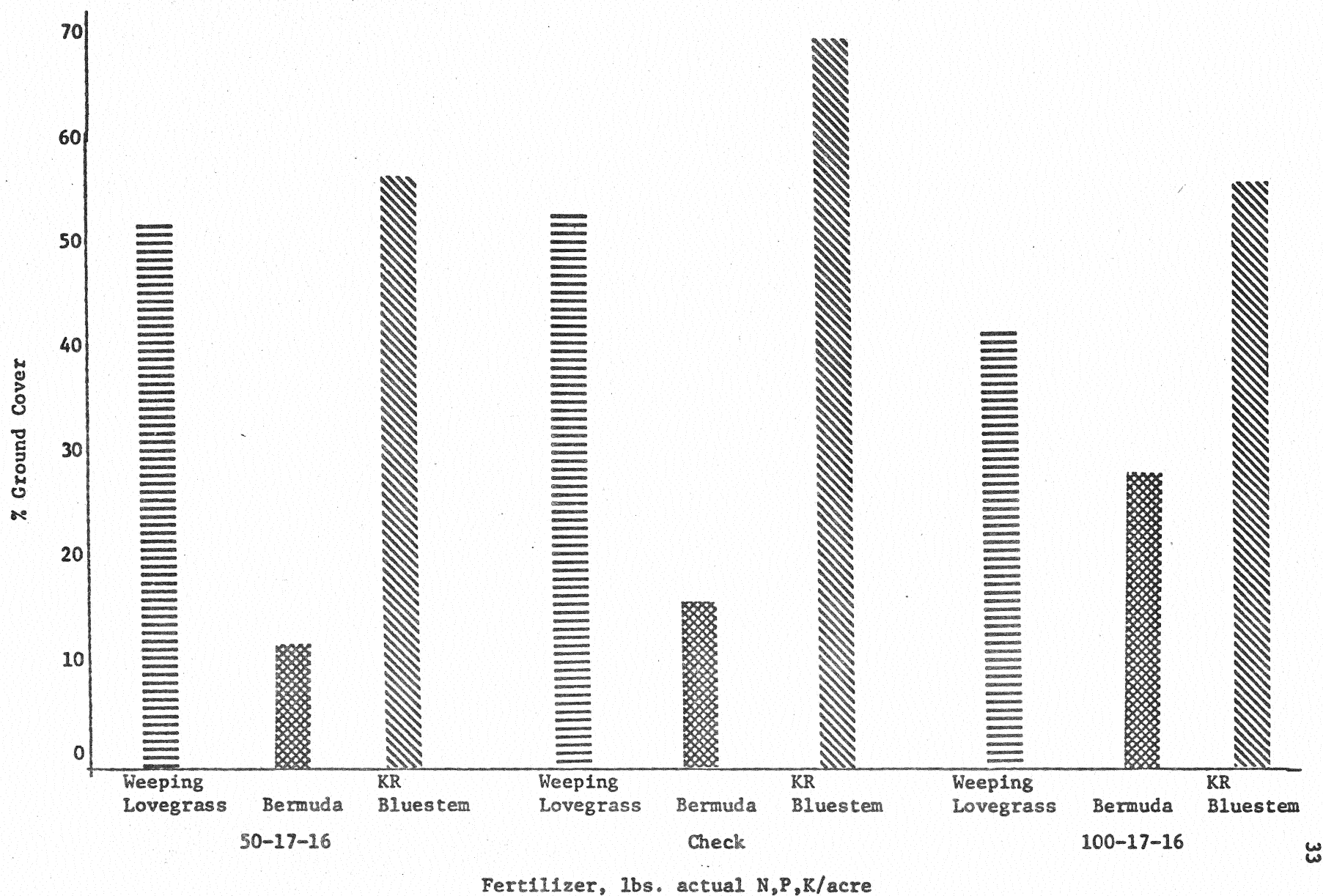


Figure 18. The effect of various fertilizers applied April 22, 1964, and retreated June 17, 1966, on the growth of three grasses on a south facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma as evaluated September 20, 1968.

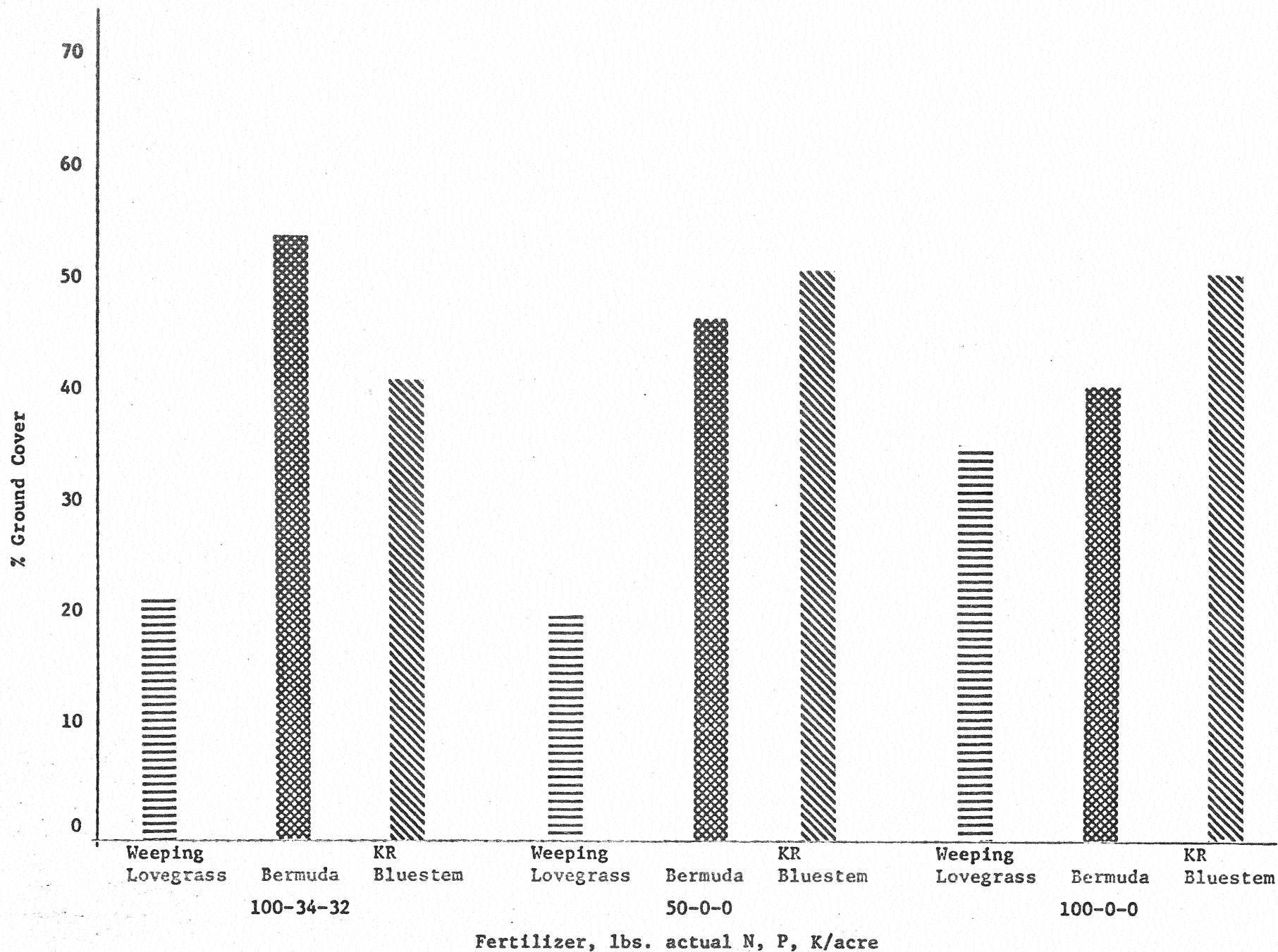


Figure 19. The effect of various fertilizers applied April 22, 1964, and retreated June 17, 1966, on the growth of three grasses on a south facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma as evaluated September 20, 1968.

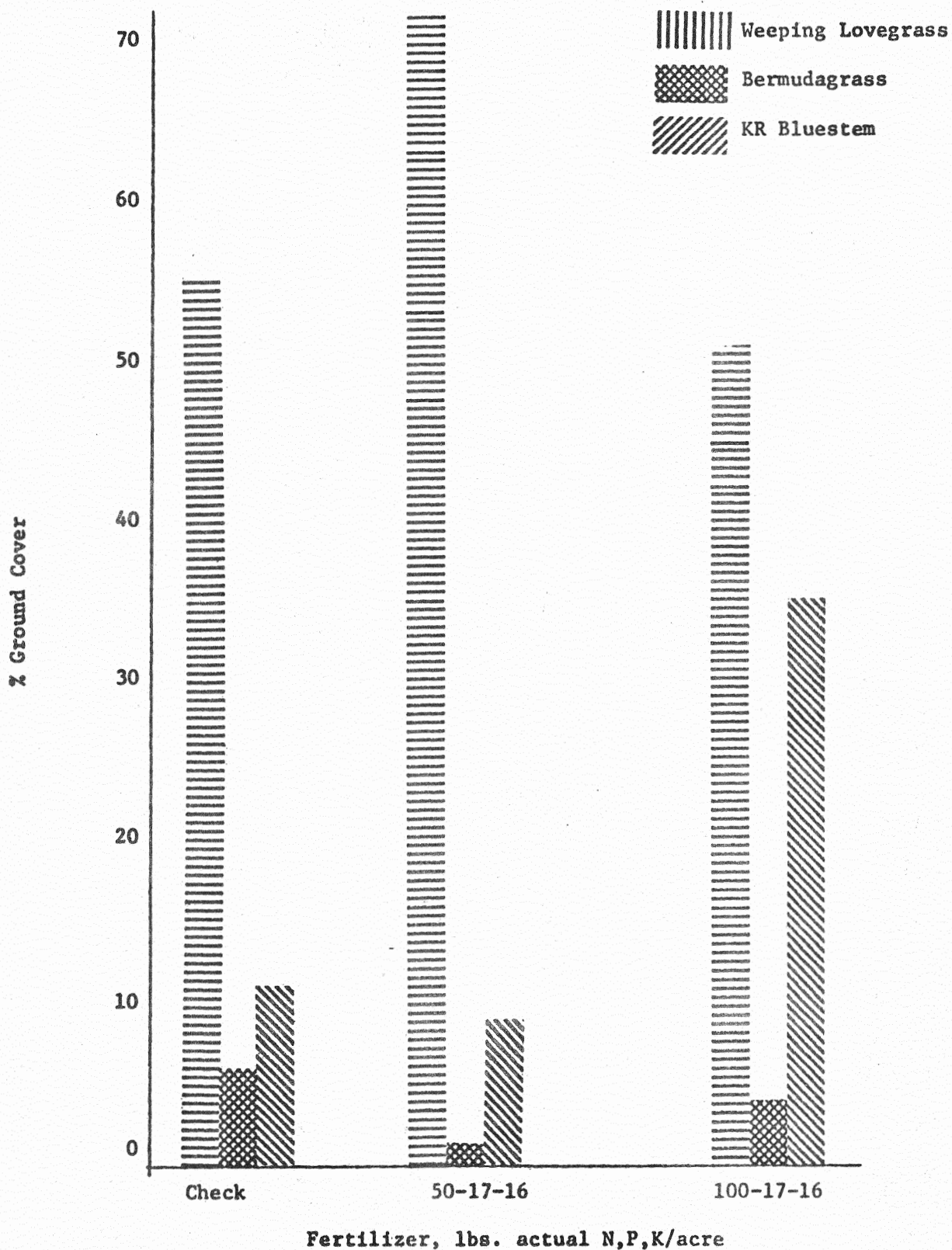


Figure 20. The effect of various fertilizers applied April 22, 1964, and retreated May 6, 1965, and June 7, 1966, on the growth of three grasses on a north facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma as evaluated September 20, 1968.

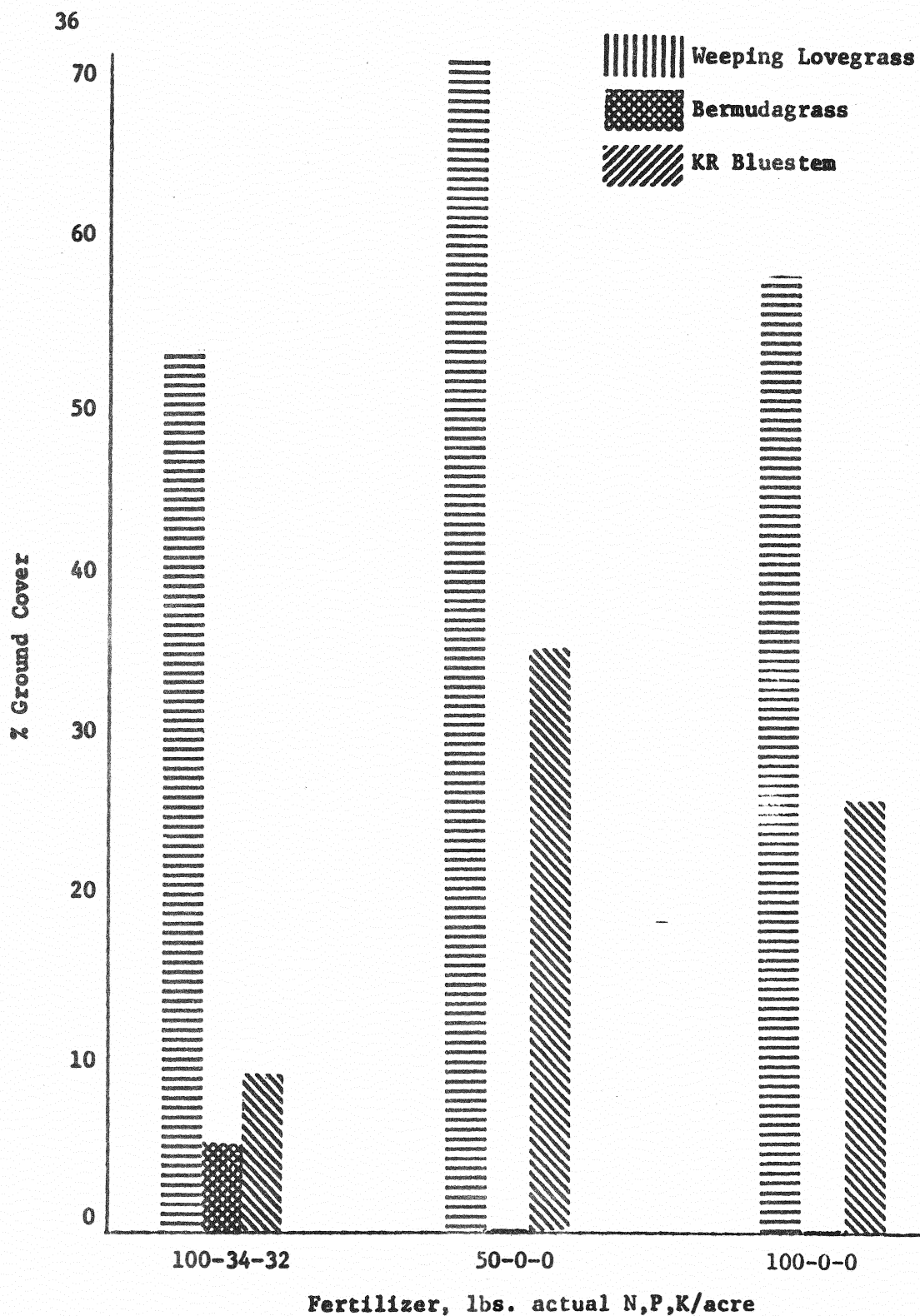


Figure 21. The effect of various fertilizers applied April 22, 1964, and retreated May 6, 1965, and June 7, 1966, on the growth of three grasses on a north facing cut slope on US-270 one and one-half miles west of SH-48 near Holdenville, Oklahoma as evaluated September 20, 1968.

A duplicate set of experiments to those described above were established on US-270 about $3\frac{1}{2}$ miles further west on a sandy loam, 3:1 backslope. In the experiment on the north side of the highway with a south facing slope, a significant difference in fertilizer treatments made in the three consecutive years 1964, 1965, and 1966 was observed two years later. The best response was obtained from the application of either 50 or 100 pounds of nitrogen alone per acre, or 100 pounds of nitrogen plus 17 pounds of phosphorus and 16 pounds of potassium as shown in Figures 22 and 23. Weeping lovegrass, the dominant vegetation, provided 45 to 50% ground cover, with bermudagrass adding another 10 to 15%. A detectable decrease in percent ground cover provided by weeping lovegrass occurred since the year before even in these better treatments. The same trend existed with bermudagrass in two of the three better treatments. For some unknown reason a 12% increase in percent ground cover provided by bermudagrass was recorded for those plots treated with 50 pounds of nitrogen per acre.

In the duplicate study (with the exception of a north exposure) on the backslope just south across US-270 no significant differences in fertilizer treatments could be detected at this time. Weeping lovegrass was practically the only grass providing a protective cover as shown in Figures 24 and 25. Switchgrass and KR bluestem previously found in this mixture was not abundant enough to measure.

Two years after the last fertilizer application on an east facing cut slope on I-35 west of Stillwater in north central Oklahoma, bermudagrass had declined 25% in ground cover in the best plots previously treated with 100-17-16 pounds of actual nitrogen, phosphorus and potassium per acre. Bermudagrass dominates in this experiment as shown in Figure 26, however, no significant differences in fertility treatments were found at this time.

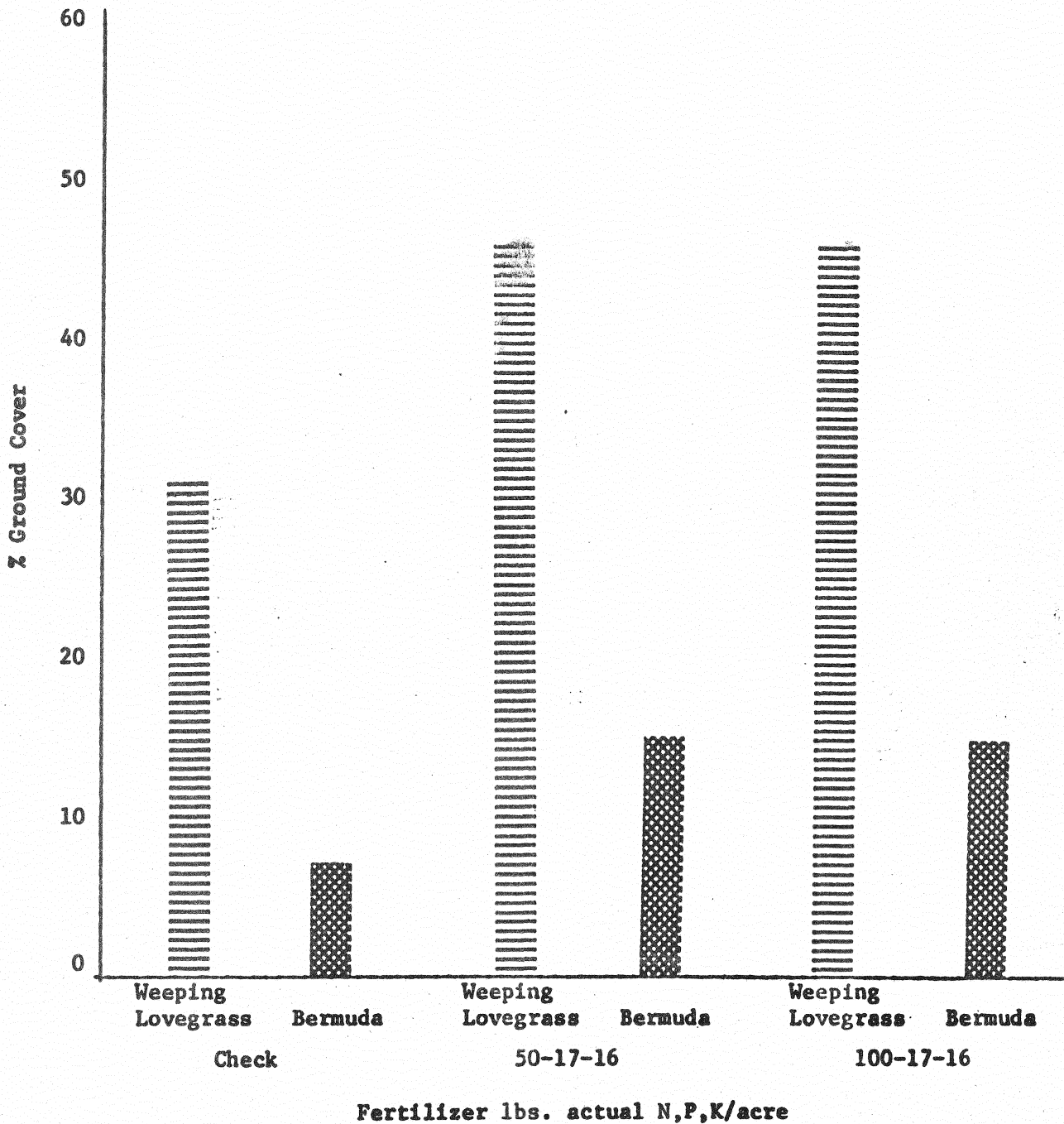


Figure 22. The effect of various fertilizers applied April 24, 1964, and retreated May 7, 1965, and June 17, 1966, on the growth of two grasses on a south facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma as evaluated September 20, 1968.

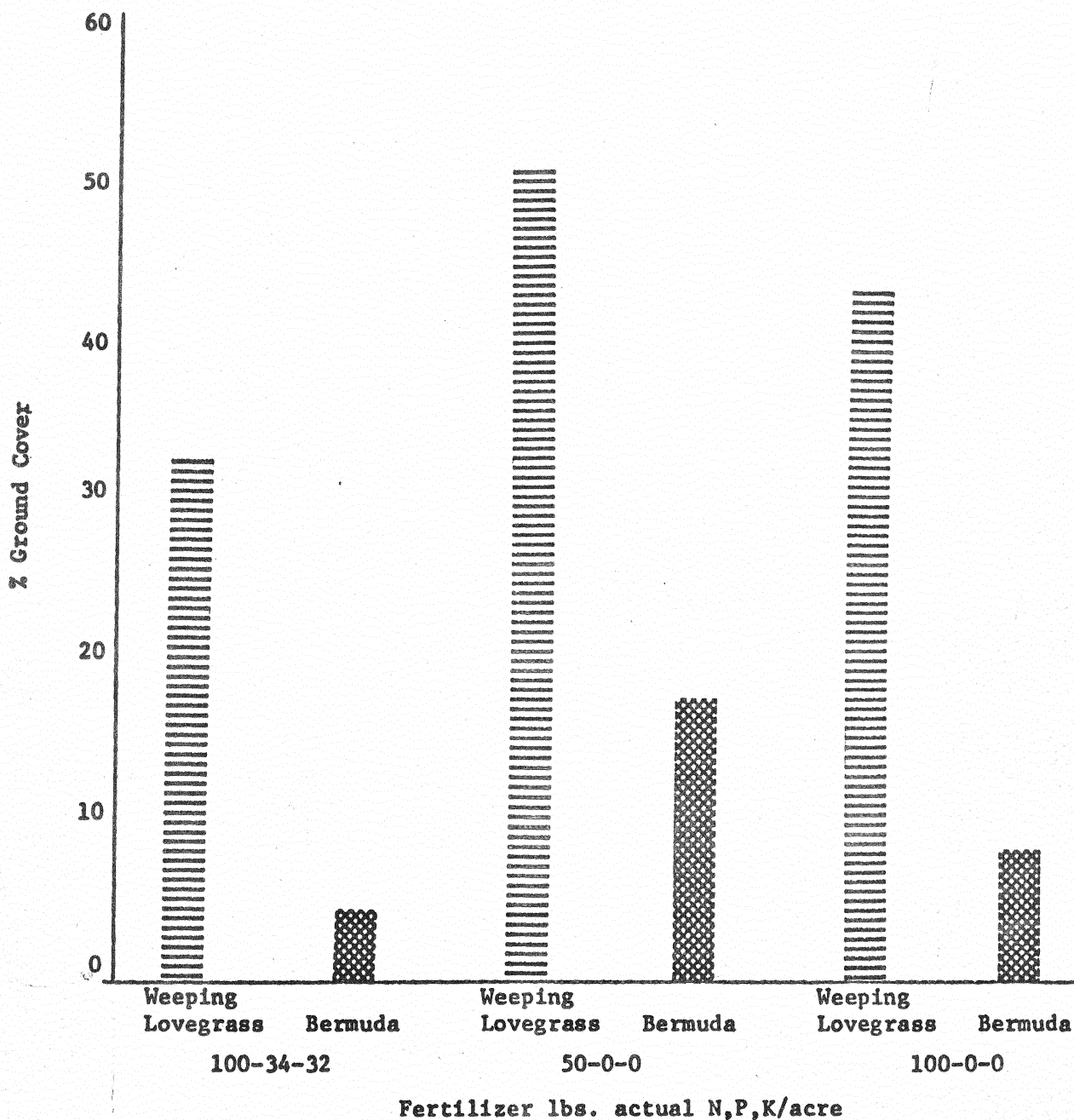


Figure 23. The effect of various fertilizers applied April 24, 1964, and retreated May 7, 1965, and June 17, 1966, on the growth of two grasses on a south facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma as evaluated September 20, 1968.

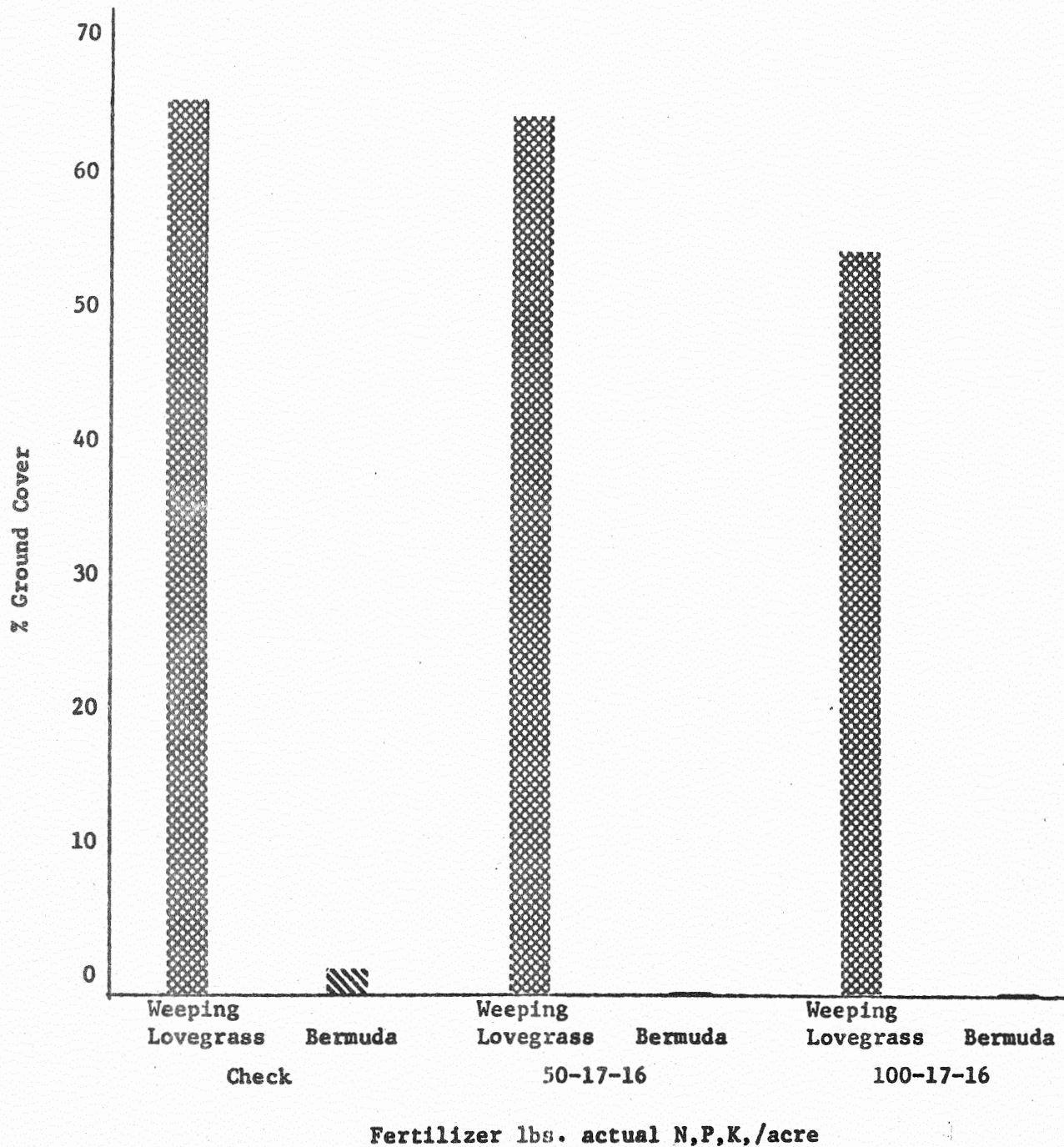


Figure 24. The effect of various fertilizers applied April 24, 1964, and retreated June 17, 1966, on the growth of two grasses on a north facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma as evaluated September 20, 1968.

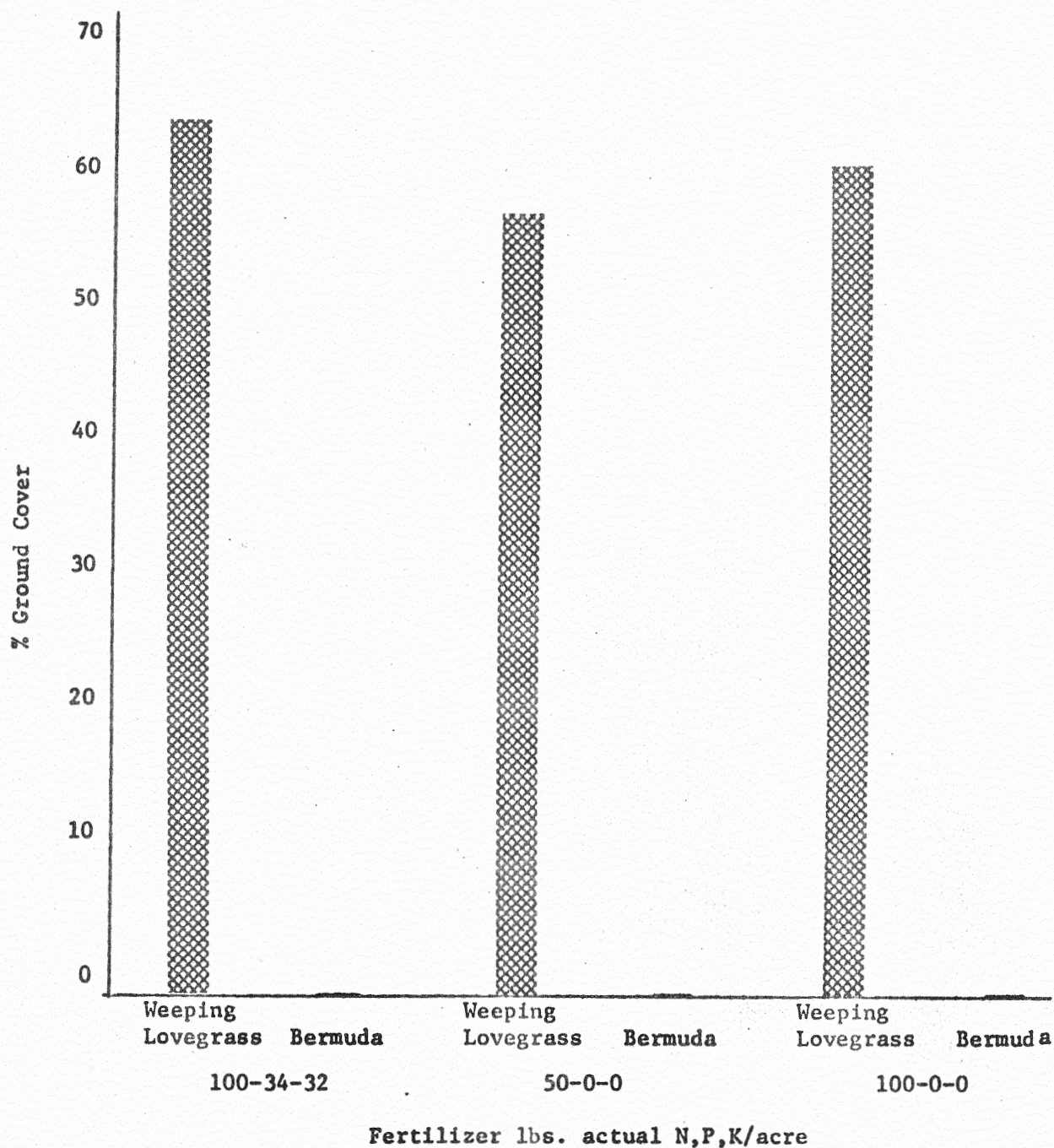


Figure 25. The effect of various fertilizers applied April 24, 1964, and retreated June 17, 1966, on the growth of two grasses on a north facing cut slope on US-270 four miles west of SH-48 near Holdenville, Oklahoma as evaluated September 20, 1968.

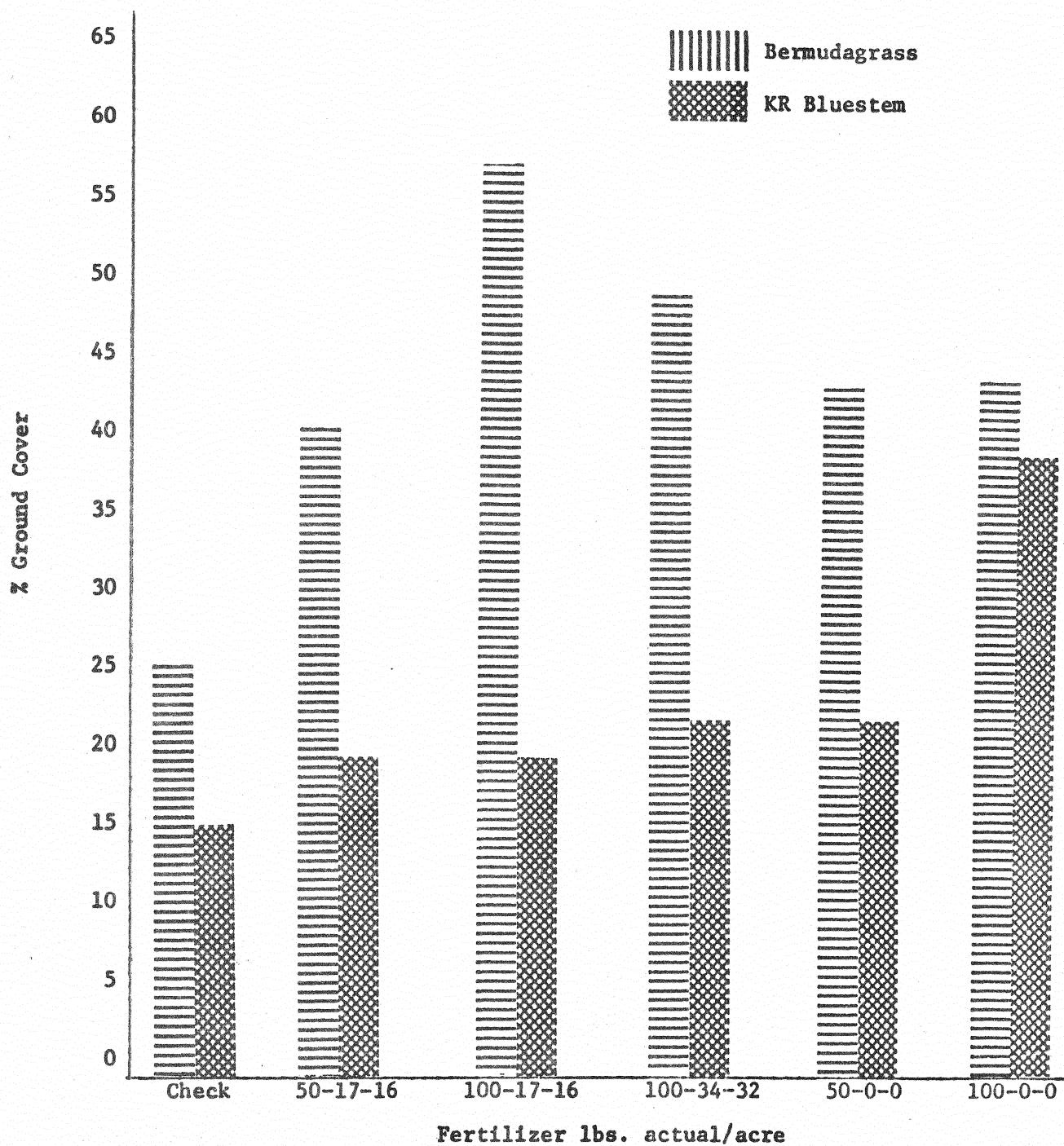


Figure 26. The effect of various fertilizers applied April 17, 1964, and retreated June 3, 1965, and June 3, 1966, on the growth of bermudagrass and KR bluestem on an east facing cut slope on I-35 three-fourths of a mile south of SH-51, as evaluated September 5, 1968.

In the duplicate experiment just across I-35 on the east side of the highway with a west facing slope a significant difference in fertilizer treatments was detected. Those plots that received phosphorus and potassium in addition to nitrogen were significantly better in the percent of ground cover than all other treatments with the exception of the ones treated with 50 pounds of nitrogen only as shown in Figure 27. Although more bermudagrass was found in the plots treated with 100 pounds of nitrogen alone, the buffalo-grass and KR bluestem in addition to the bermudagrass provided more total ground cover in those plots fertilized with only 50 pounds of nitrogen per acre. The amount of bermudagrass in the four better treatments declined from 3 to 14% ground cover from the year before.

An experiment initiated in 1966 on US-277 northwest of Shawnee adjacent to I-40 was designed to measure the effects of fertilizer on the growth of bermudagrass when combined with a herbicide for weed control. The application of nitrogen and phosphorus combined produced more ground cover than either applied alone especially if Banvel-D at one pound i.a./acre is used to control broadleaf weeds as shown in Figures 28 through 31. Those plots treated 3 years in succession with 100-34-0 with no broadleaf weed control had less percent ground cover than those treated the two consecutive years of 1966 and 1967. This may indicate that an increase in soil fertility level to this extent, without subsequent weed control, encourages the broadleaf weed growth to the detriment of the bermudagrass as shown in Figure 28.

In the experiment on I-40 located 3.6 miles east of SH-58 near Hydro in western Oklahoma no significant differences in fertilizer treatments could be detected two years after the last application in the percent ground cover on this north facing cut slope. In all plots except the highest fertility treatment, switchgrass was the most abundant grass with sideoats grama as the

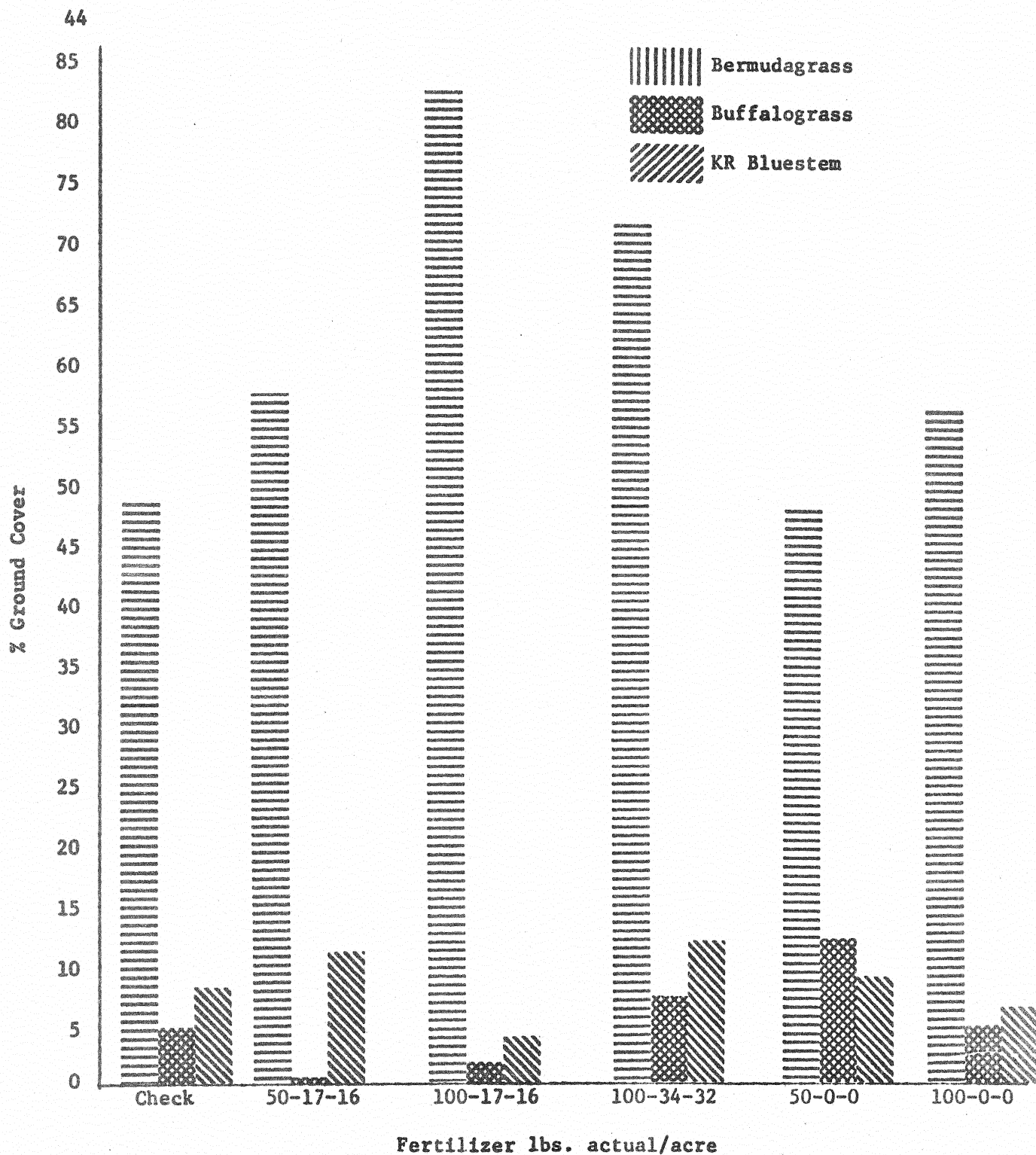


Figure 27. The effect of various fertilizers applied April 18, 1964, and retreated June 3, 1965, and June 3, 1966, on the growth of three grasses on a west facing cut slope on I-35 three-fourths of a mile south of SH-51 junction as evaluated September 5, 1968.

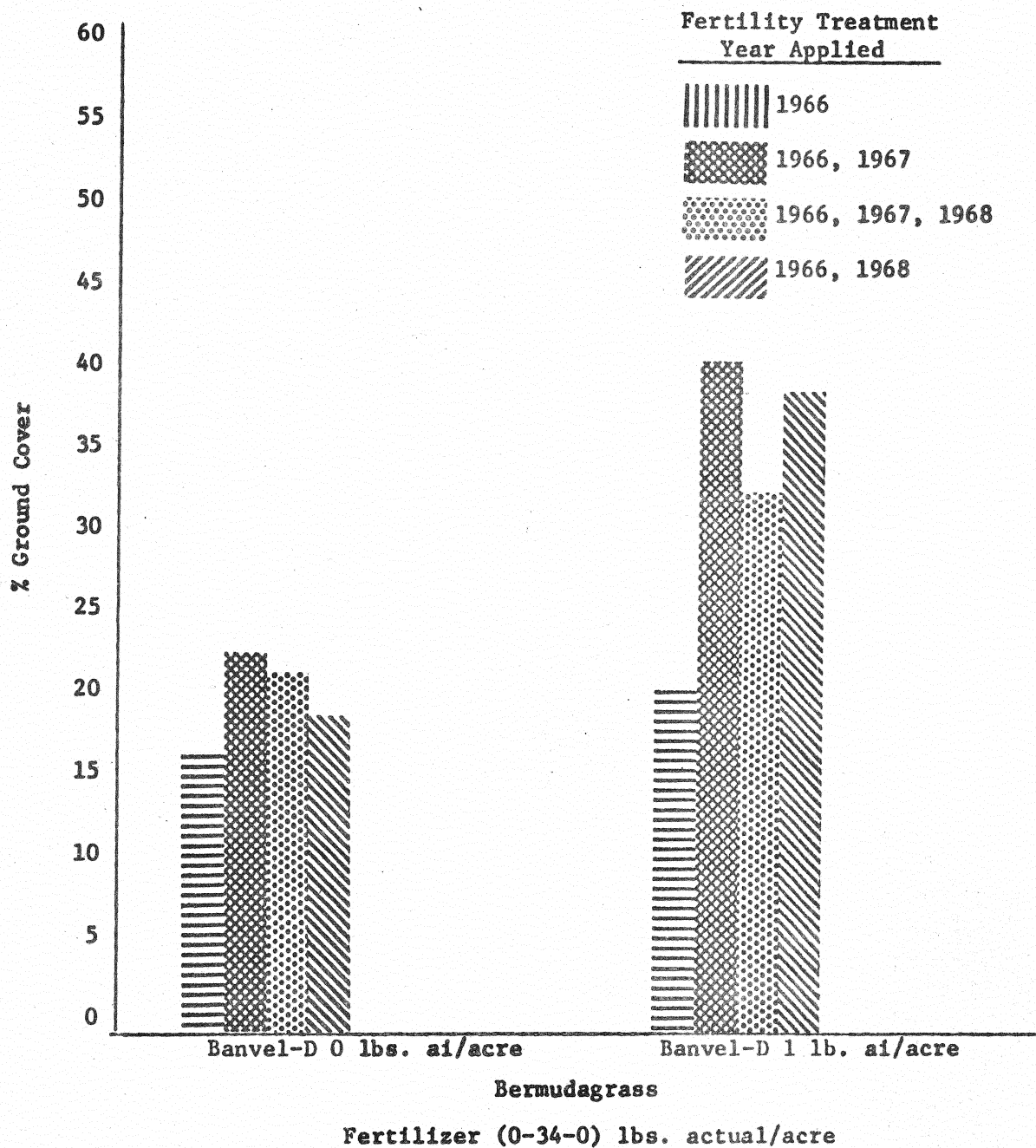


Figure 30. The effect of various fertilizers and two rates of Banvel-D on the growth of bermudagrass applied June 28 and August 5, 1966 on US-177 Northwest of Shawnee adjacent to I-40 as evaluated November 1, 1968.

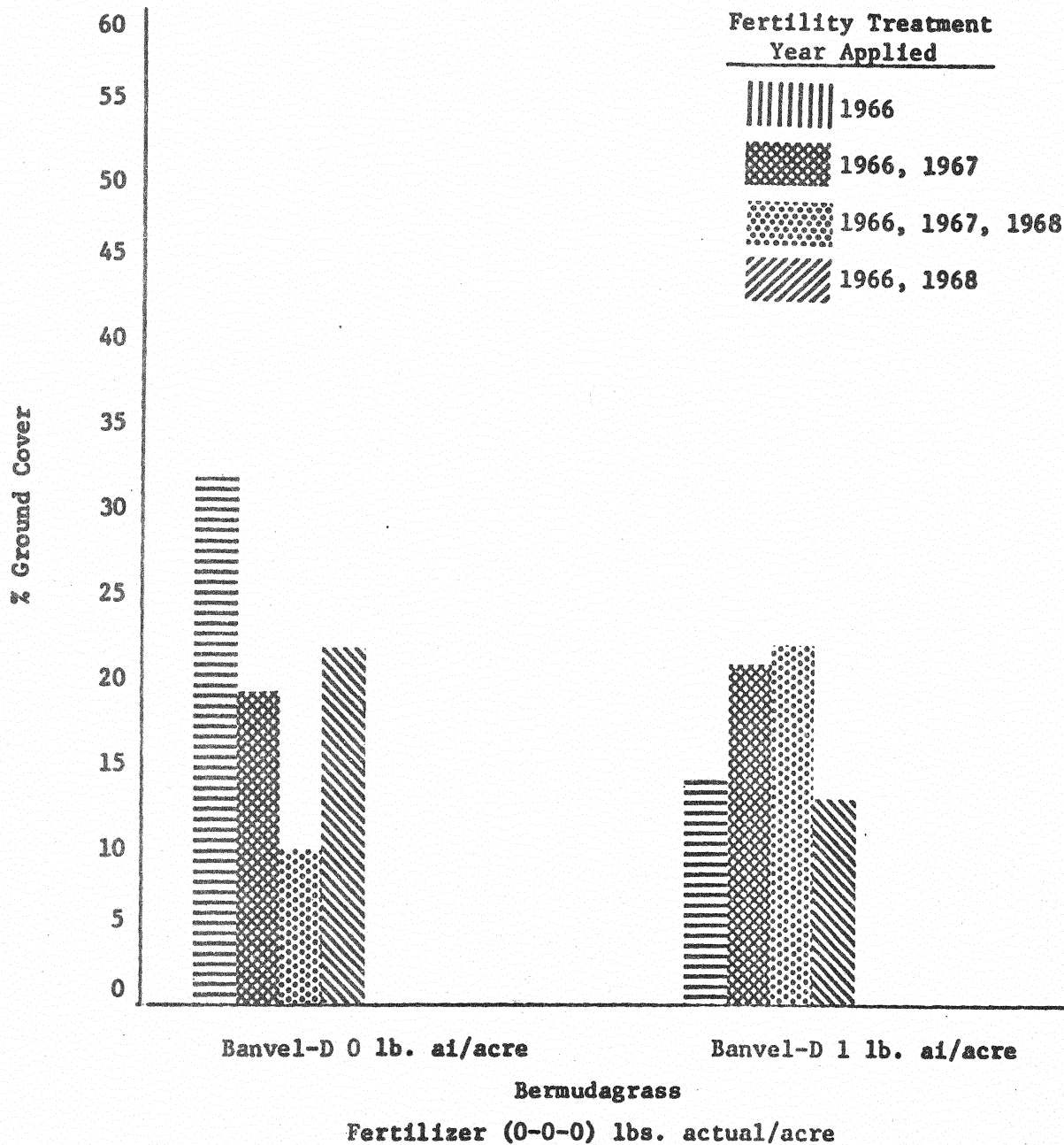


Figure 31. The effect of various fertilizers and two rates of Banvel-D on the growth of bermudagrass applied June 28 and August 5, 1966 on US-177 northwest of Shawnee adjacent to I-40 as evaluated November 1, 1968.

one exception as shown in Figure 32. This supports the statement on page xii of the Final Report of Oklahoma Project 63-03-3, Part II, which pointed out for those areas west of US-81 switchgrass is equally well adapted as sideoats grama generally east of the panhandle, for use on north facing slopes of all the grasses tested. Whereas switchgrass and sideoats grama tended to show a trend toward decreased population from the year before, on the contrary, weeping lovegrass tended to show a gradual increase in percent ground cover in all treatments since 1966.

On a north facing fill slope about one-half mile west of the above experiment on I-40, no significant differences could be detected in the percent bermudagrass ground cover shown in Figure 33. A trend showing a decline although small at this time, in the amount of ground cover is developing. This tends to indicate on these soils especially on a north facing slope, bermudagrass may need to be fertilized every other year or maybe every third year to maintain a given amount of ground cover for erosion control. The magnitude of the change in ground cover in the next year or two should indicate the frequency of fertilization required for maintenance of bermudagrass on a north facing fill slope in this area.

Further west about one-fourth mile from the above experiment on I-40 a highly significant difference in fertilizer treatments was found two years after the last application in the amount of ground cover provided by the three grasses, weeping love, switch, and sideoats grama. The responses of these three grasses to the six fertility treatments are shown in Figure 34.

The greatest response, as measured by the percent ground cover provided by these three grasses, was obtained from the application of 50 pounds of nitrogen alone in each of three consecutive years. Sideoats grama, followed rather closely by switchgrass generally provided the most ground cover. In

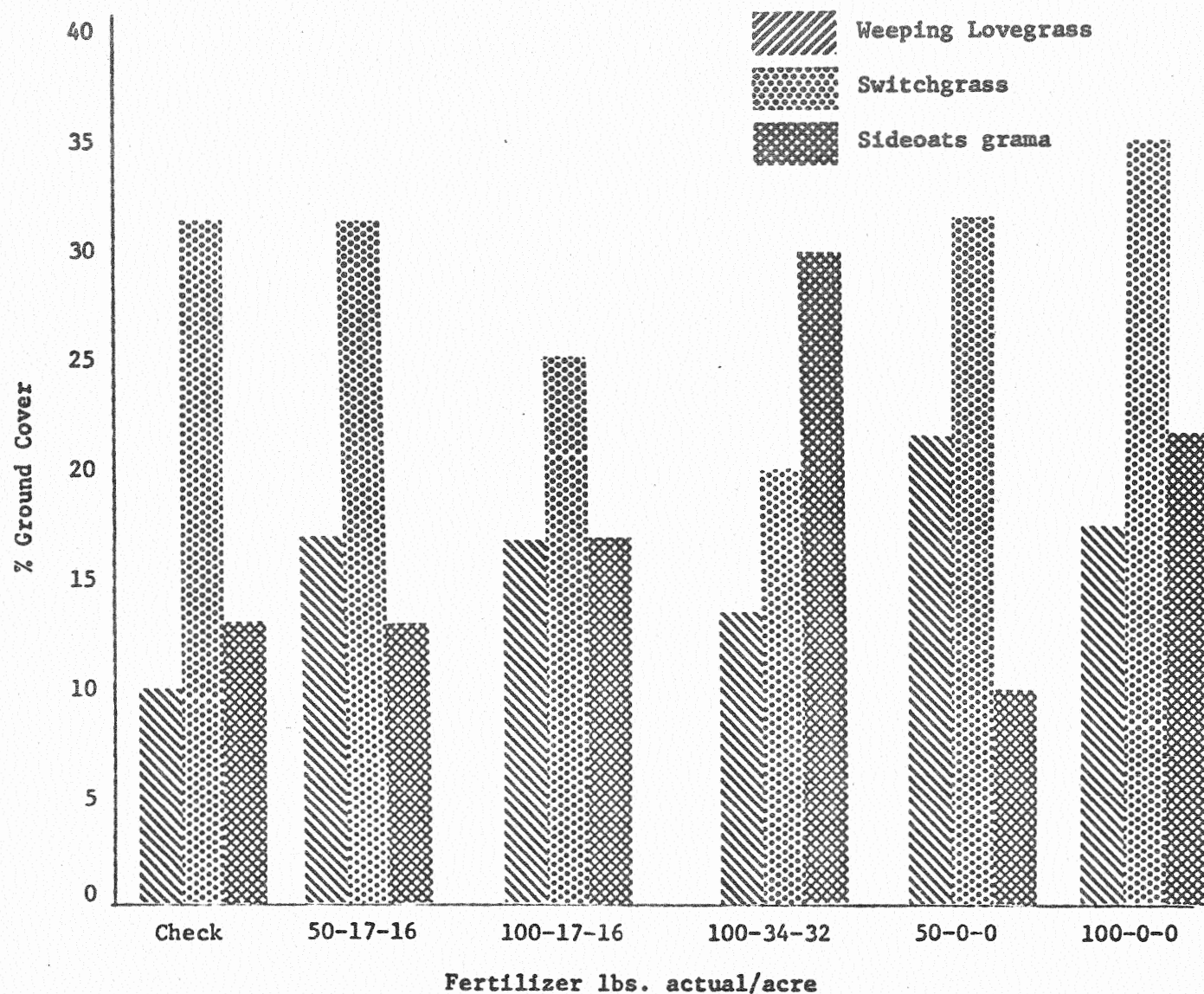


Figure 32. The effect of various fertilizer rates applied May 13, 1964, and retreated June 2, 1965, and June 15, 1966 on the growth of three grasses on a north facing cut slope 3.6 miles east of SH-58 on I-40 near Hydro, Oklahoma as evaluated September 18, 1968.

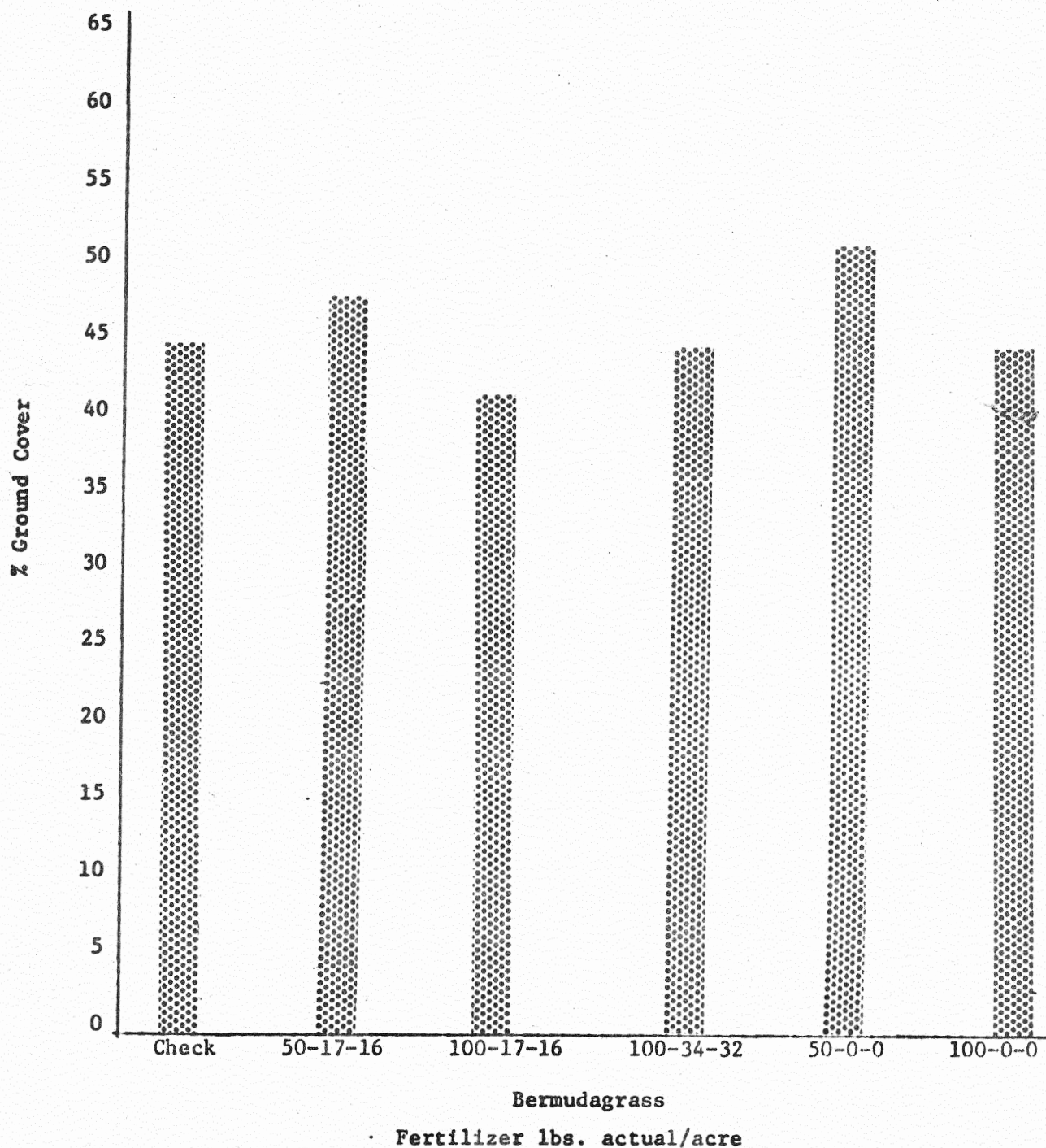


Figure 33. The effect of various fertilizer rates applied May 20, 1964, and retreated June 2, 1965, and June 15, 1966, on the growth of bermudagrass on a north facing fill slope 4.2 miles east of SH-58 on I-40 near Hydro, Oklahoma as evaluated September 18, 1968.

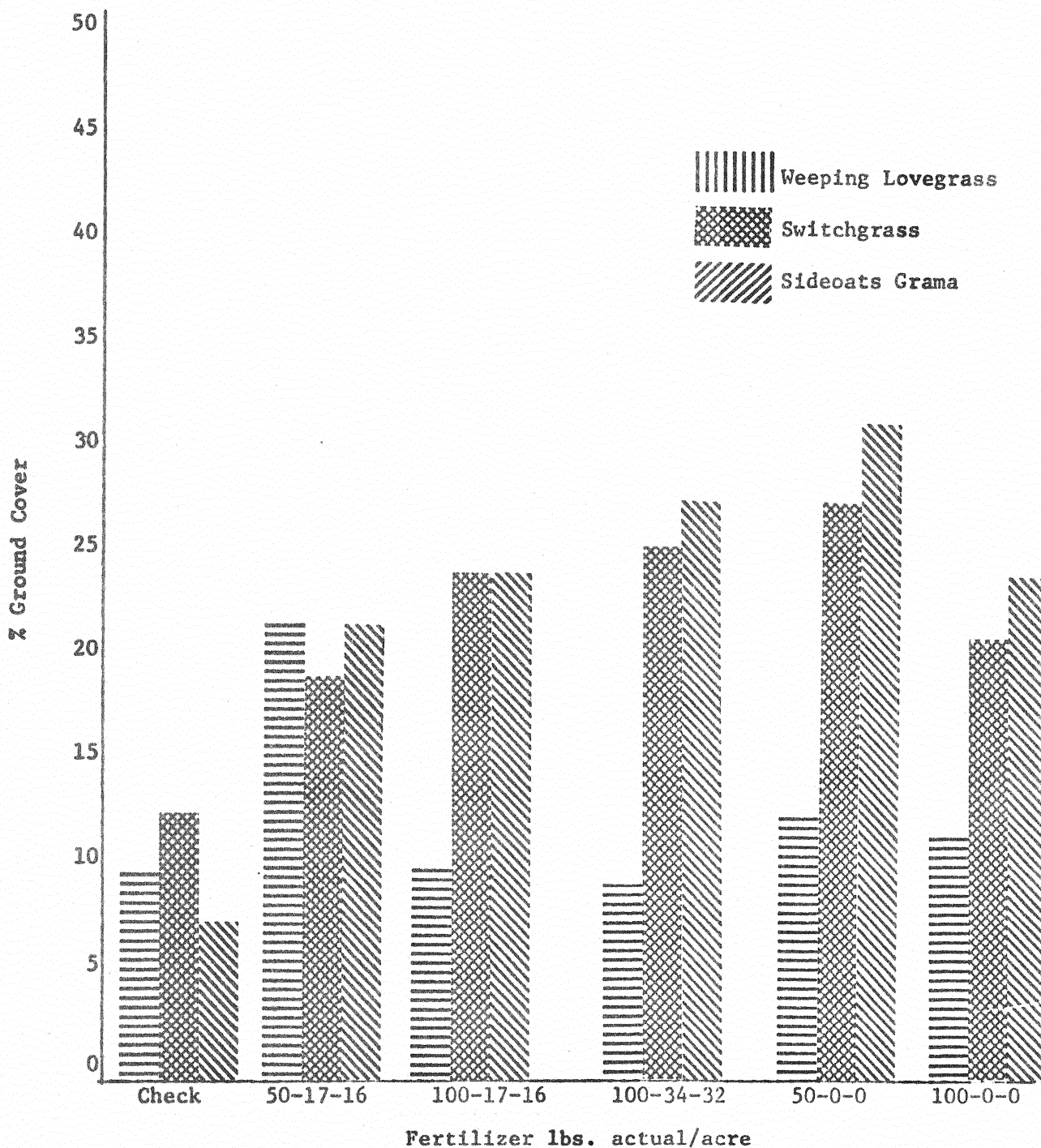


Figure 34. The effect of various fertilizer rates applied May 13, 1964, and retreated June 3, 1965, and June 15, 1966, on the growth of three grasses on a north facing cut slope 4.5 miles east of SH-58 on I-40 near Hydro, Oklahoma as evaluated September 18, 1968.

the plots that received no fertilizer switchgrass was found to provide more ground cover than weeping lovegrass and both were better than sideoats. These data would tend to indicate that nitrogen is the only fertilizer needed on north facing cut slopes in this area to provide good ground cover from sideoats, switch, and weeping lovegrass. All fertilizer treatments were strikingly better than the check in the amount of ground cover produced. This supports in general the statement on page x of the Final Report of Oklahoma Project 63-03-3, Part II for areas west of US-81 which points out for all grass mixtures on all slopes apply 100 pounds of nitrogen per acre per application once every 2 to 3 years for maintenance. These later data tend to indicate that perhaps half this amount or 50 pounds of nitrogen per acre would be adequate. This would amount to a substantial savings in maintenance if further research findings support these results.

Across the road north from the above investigation on I-40 near Hydro (in western Oklahoma) no significant differences in fertilizer treatments could be detected however, a definite change in plant composition is starting to appear. With but one exception, weeping lovegrass now provides more ground cover than sideoats grama as shown in Figure 35. Previously they were rather evenly divided among treatments, each slightly more abundant in three of the six treatments. Switchgrass shows a definite decline in abundance in this experiment.

The duplicate experiments established in northwest Oklahoma on opposite sandy loam backslopes, on State Highway 34 (about seven miles north of US-64) northeast of Buffalo, to evaluate four fertilizer treatments and four application periods was terminated with the completion of Project 63-03-3, before all treatments could be applied. Instead of four different treatment dates there were only two. No treatments were applied as planned originally in 1968. No significant differences in treatments could be detected in the west facing

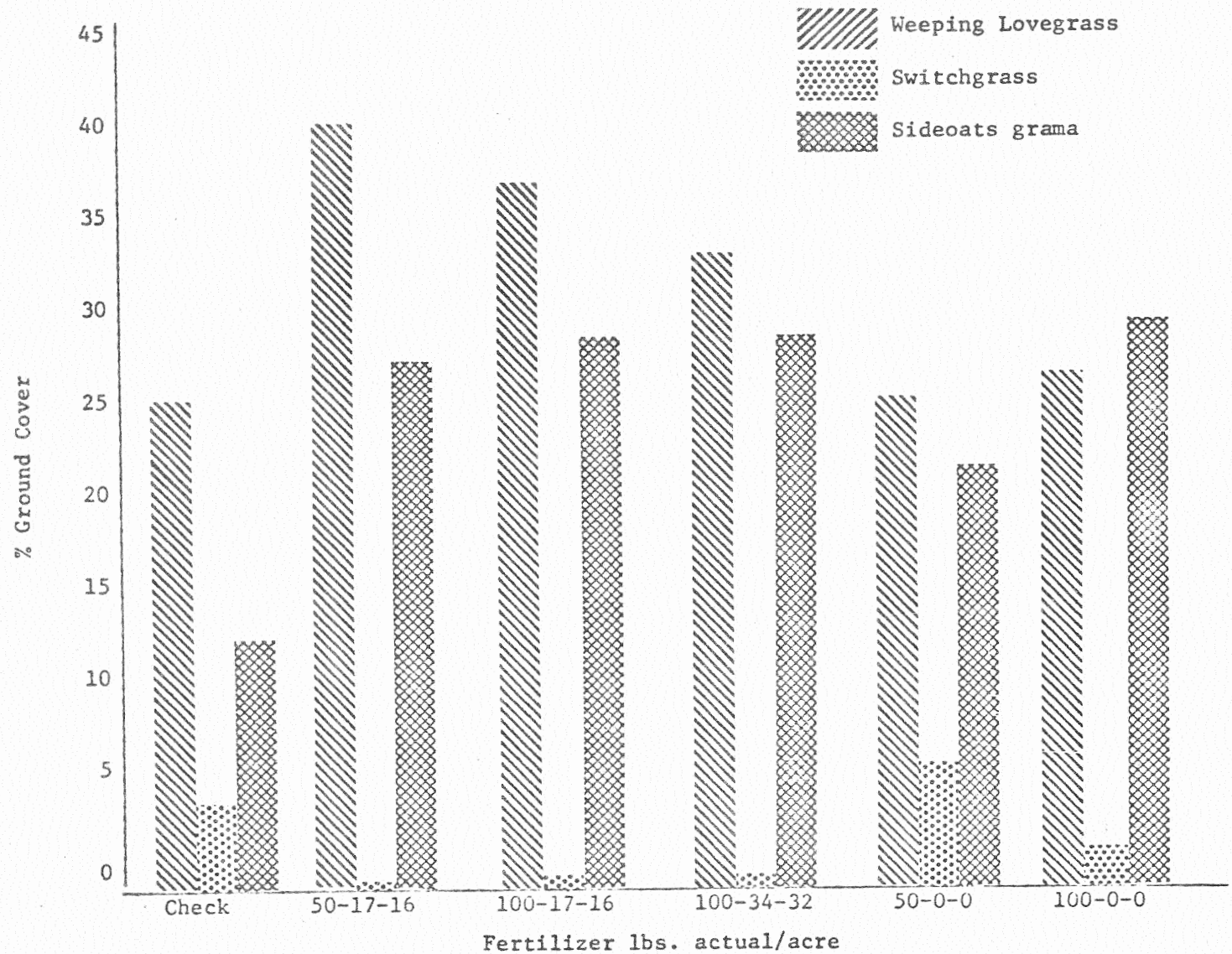


Figure 35. The effect of various fertilizer rates applied May 20, 1964, and re-treated June 2, 1965, and June 15, 1966, on the growth of three grasses on a south facing cut slope 4.5 miles east of SH-56 on I-40 near Hydro, Oklahoma as evaluated September 18, 1968.

experiment on the east side of the highway, in the amount of ground cover provided by the three grasses, buffalo, sideoats, and weeping lovegrass as shown in Figures 36 through 38. In general, those plots fertilized in each of two consecutive years produced more ground cover than those fertilized only once.

In the duplicate experiment (except an east facing slope) across the highway west (SH-34) a highly significant difference in treatments was found. Those plots that received the 100 pounds of nitrogen with 34 pounds of phosphorus in each of two successive years had the greatest amount of ground cover. The results of these treatments are shown in Figures 39 and 40. Sideoats grama was the most abundant grass in this experiment, followed rather closely by weeping lovegrass and buffalo. The application of phosphorus alone did not produce any more ground cover than was obtained in the unfertilized plots.

In the same area as the above experiments on SH-34, but on east and west facing fill slopes sprigged to bermudagrass in 1964, no significant differences could be found in fertility treatments on either slope. In the east facing slope experiment the most ground cover was produced with the application of both nitrogen and phosphorus as shown in Figure 41. These treatment differences should become more evident within a few more years. The fertility level from the initial application at the time of sprigging is providing for a little more than 45% ground cover. A difference of about 15% in amount of ground cover now exists between the check plots and those that received two applications of 100-34-0. Within a few more years this variation will undoubtedly become greater, pointing out a need for periodic applications of fertilizer for maintenance, especially for bermudagrass.

Across the highway from the above experiment with a west facing fill slope no significant differences in fertilizer treatment could be detected in the amount of ground cover provided by bermudagrass. The most bermudagrass was found in those plots treated with 100 pounds of nitrogen per acre with

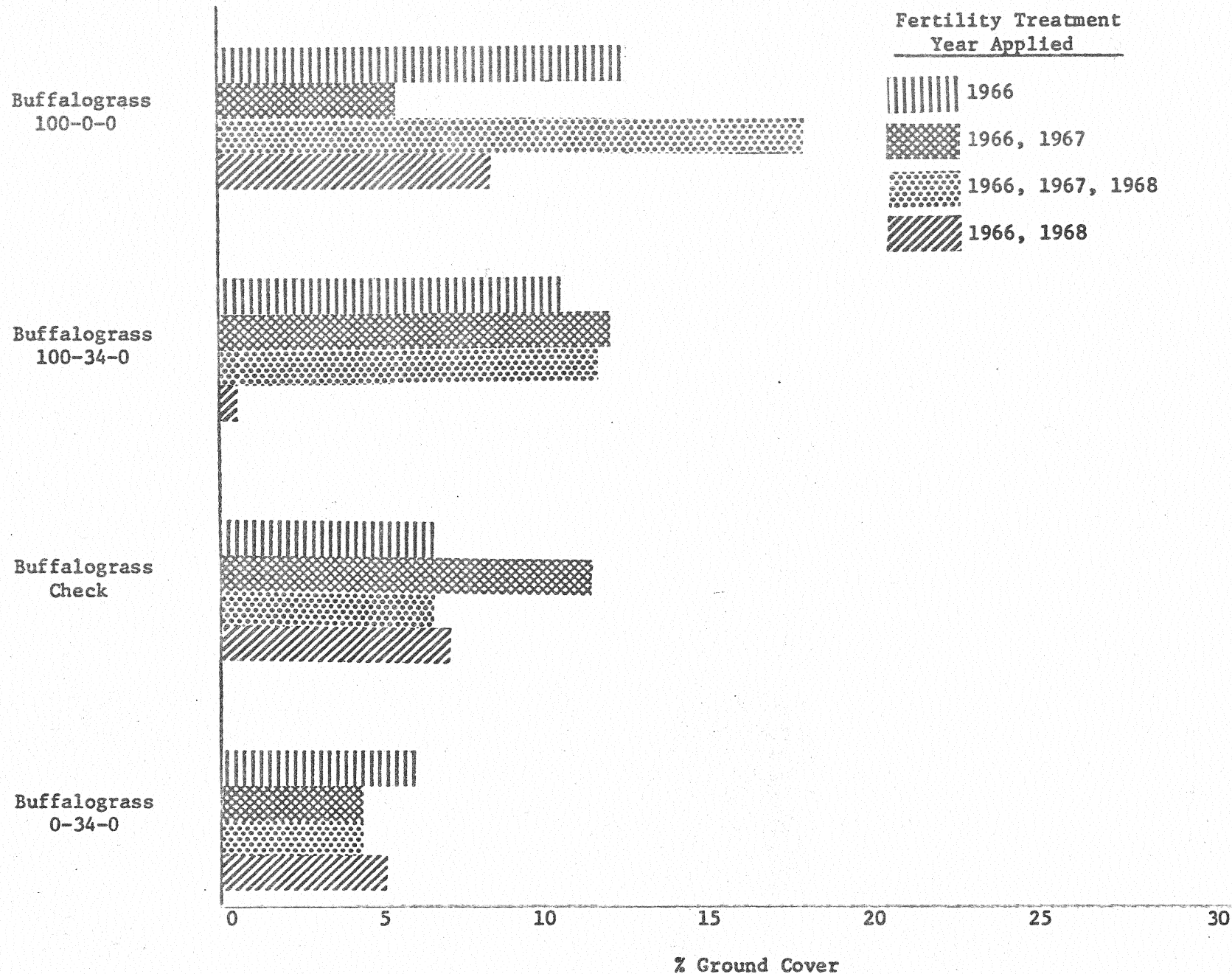


Figure 36. The effect of various fertilizer rates and frequency of application on the growth of three grasses for erosion control on SH-34 on a west facing cut slope seven miles north of US-64 west of Alva, Oklahoma as evaluated on August 7, 1968. Fertilizers were applied July 14, 1966, and again July 21, 1967.

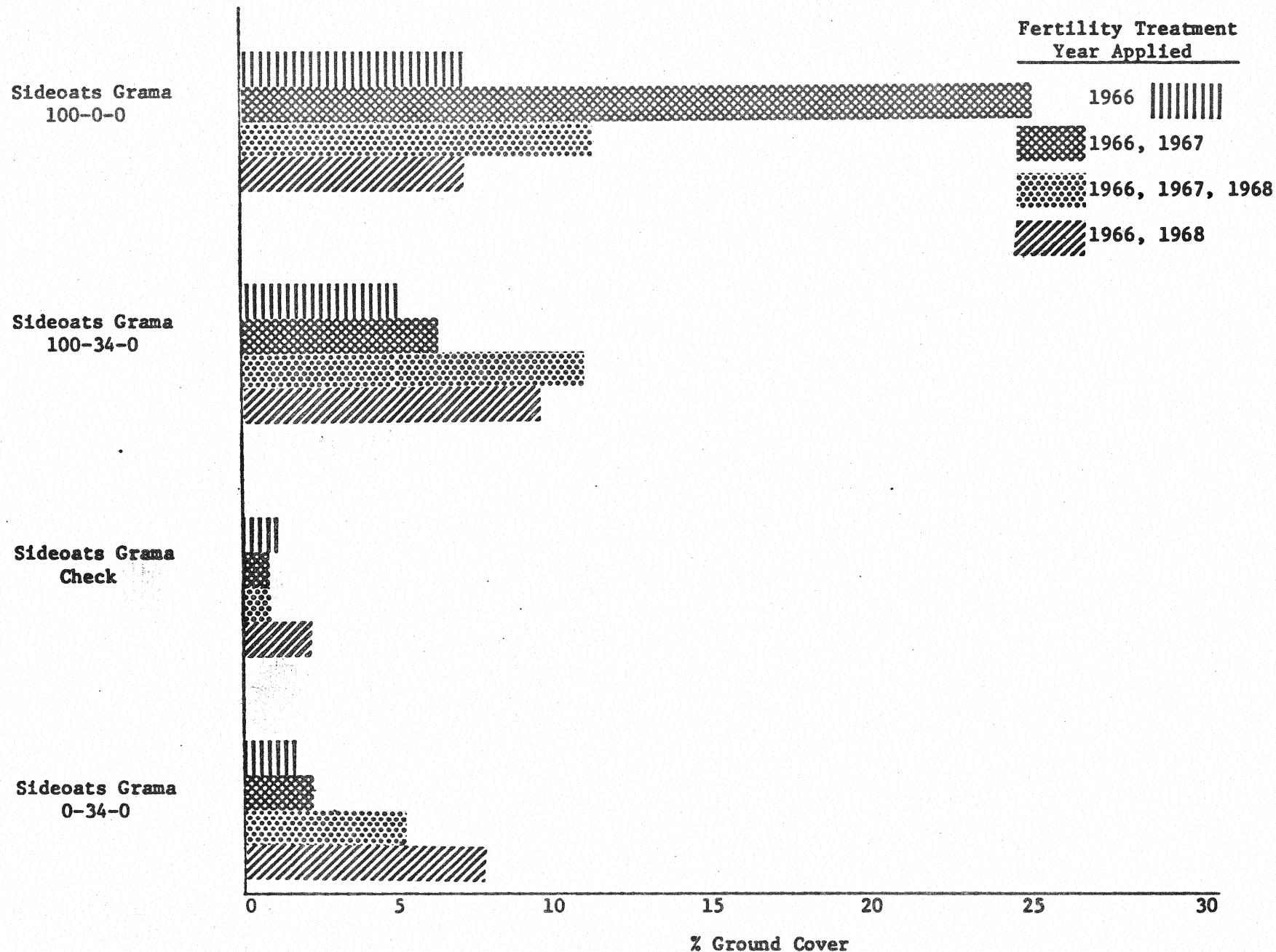


Figure 37. The effect of various fertilizer rates and frequency of application on the growth of three grasses for erosion control on SH-34 on a west facing cut slope seven miles north of US-64 west of Alva, Oklahoma as evaluated on August 7, 1968. Fertilizers were applied July 14, 1966, and again July 21, 1967.

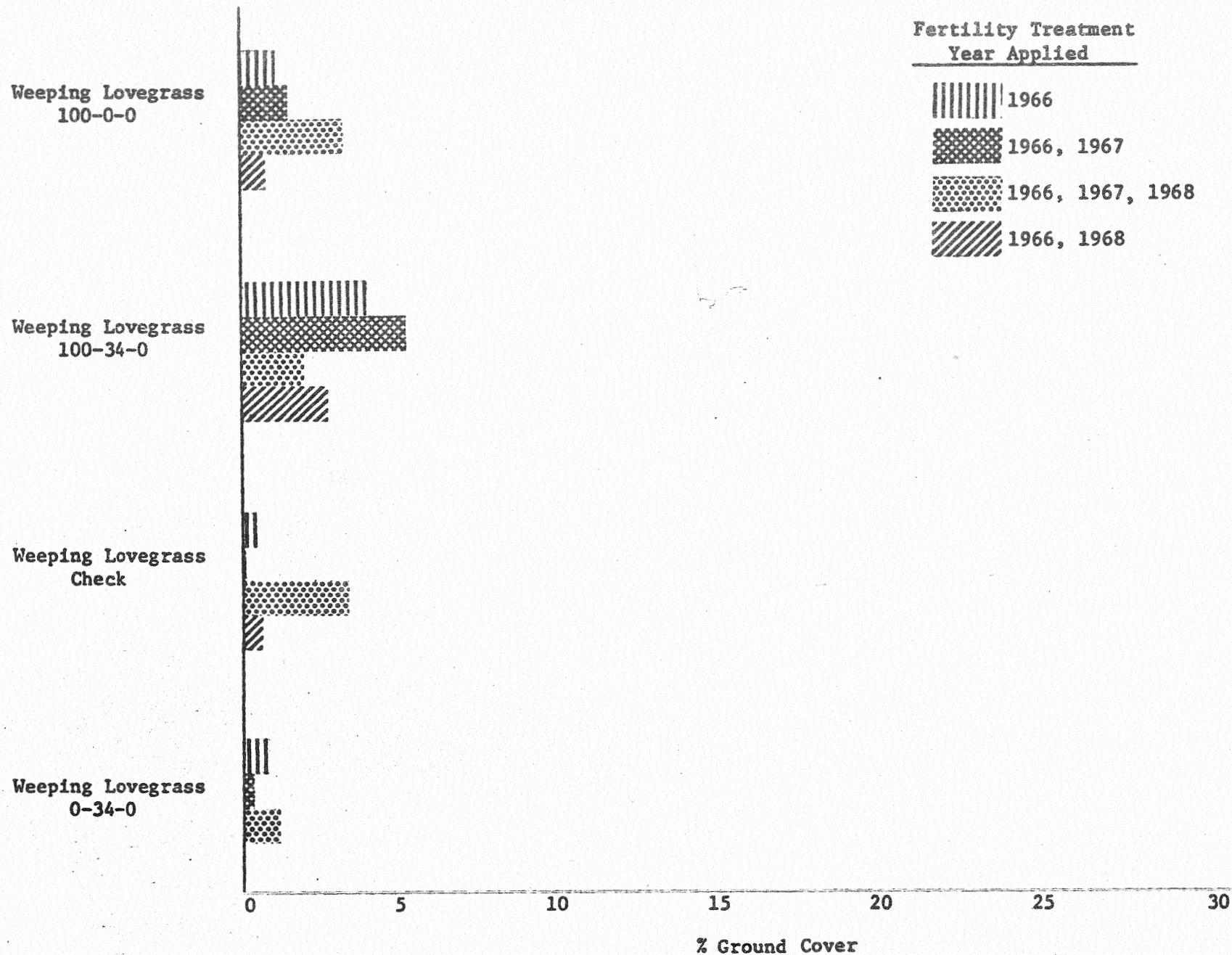


Figure 38. The effect of various fertilizer rates and frequency of application on the growth of three grasses for erosion control on SH-34 on a west facing cut slope seven miles north of US-64 west of Alva, Oklahoma as evaluated on August 7, 1968. Fertilizers were applied July 14, 1966, and again July 21, 1967.

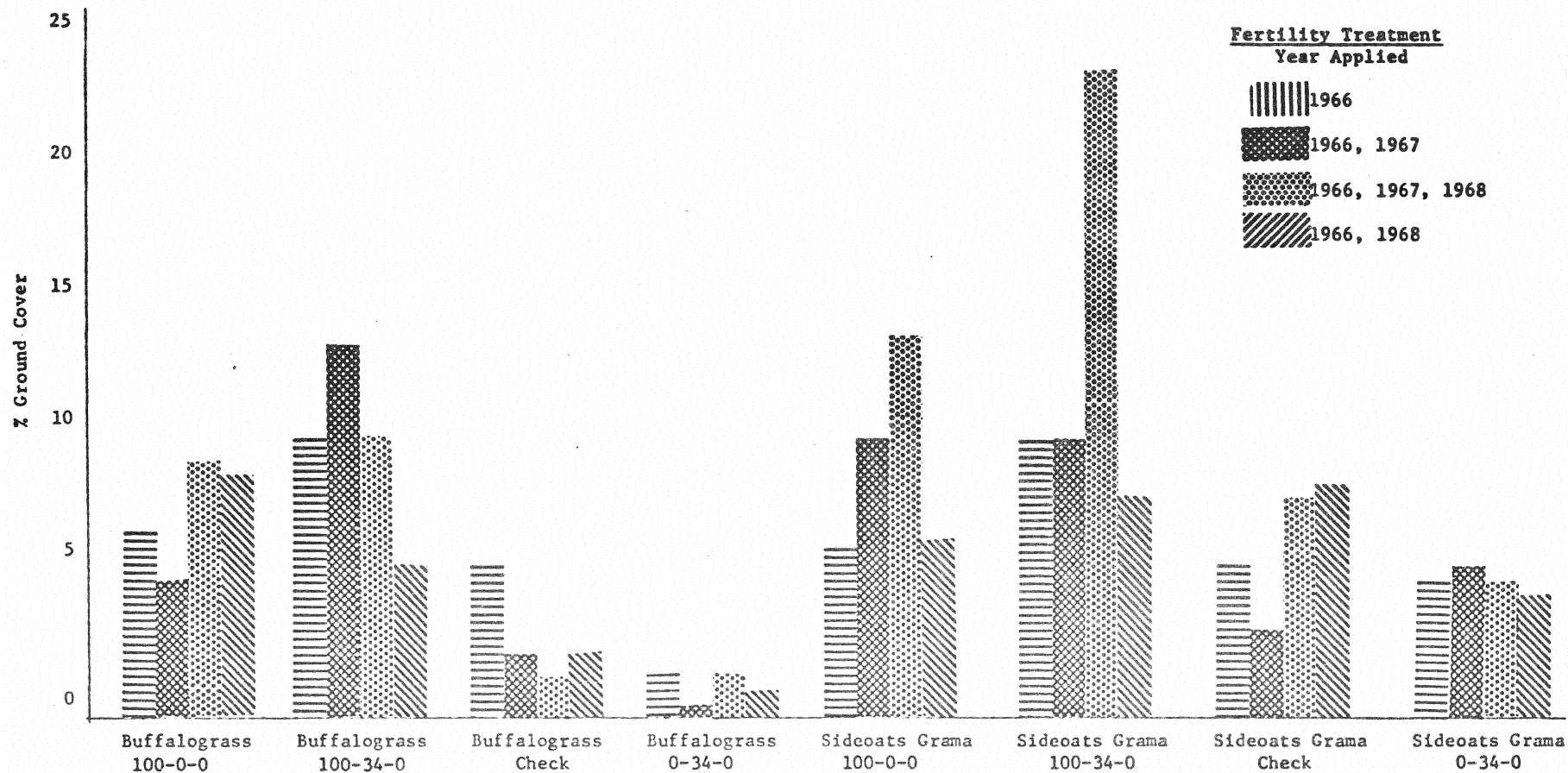


Figure 39. The effect of various fertilizer rates and frequency of application on the growth of three grasses for erosion control on SH-34 on an east facing cut slope seven miles north of US-64 west of Alva, Oklahoma. Fertilizers were applied July 14, 1966, and again on July 21, 1967. Evaluated August 7, 1968.

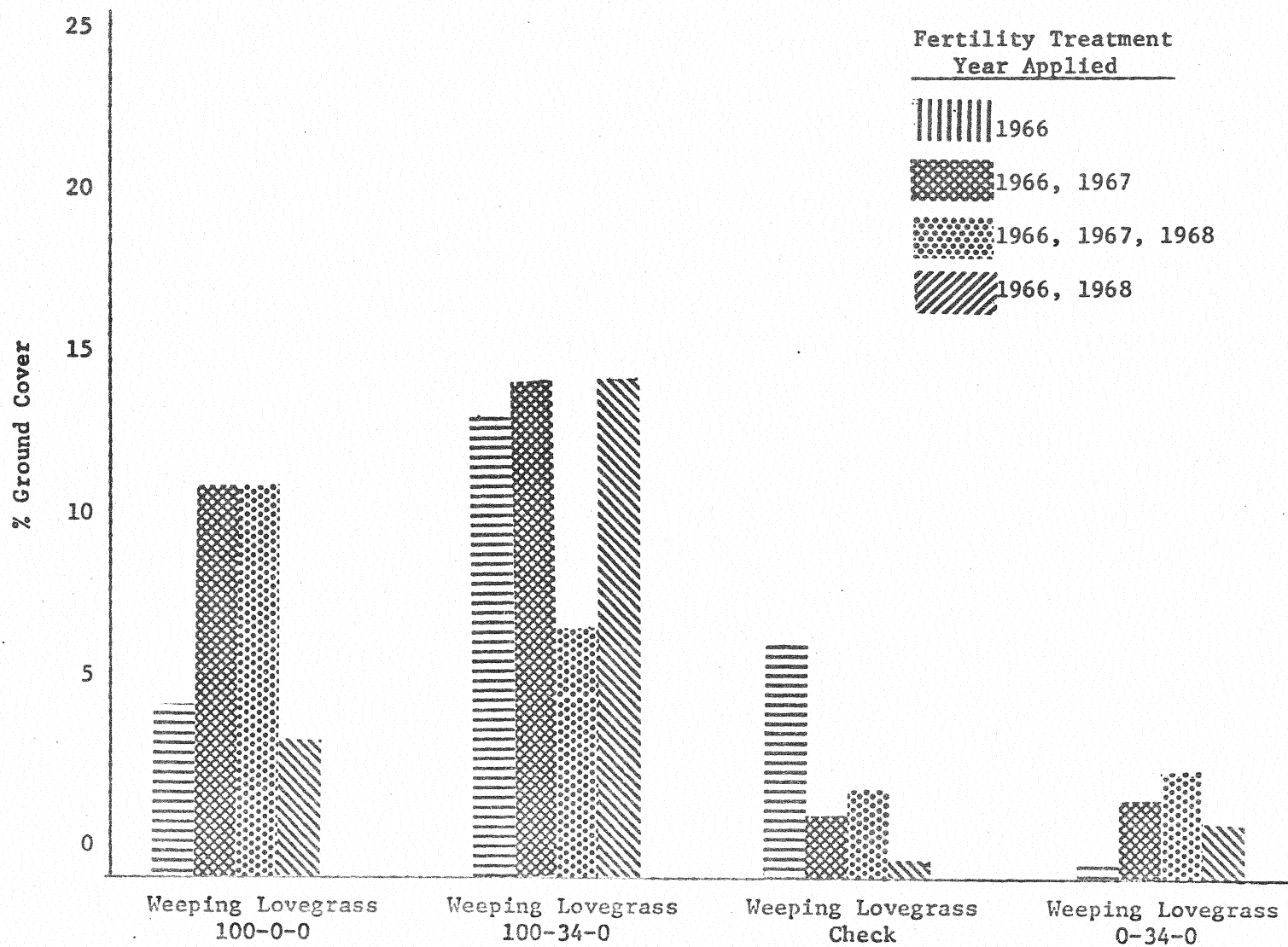


Figure 40. The effect of various fertilizer rates and frequency of application on the growth of three grasses for erosion control on SH-34 on an east facing cut slope seven miles north of US-64 west of Alva, Oklahoma. Fertilizers were applied July 14, 1966, and again on July 21, 1967. Evaluated August 7, 1968.

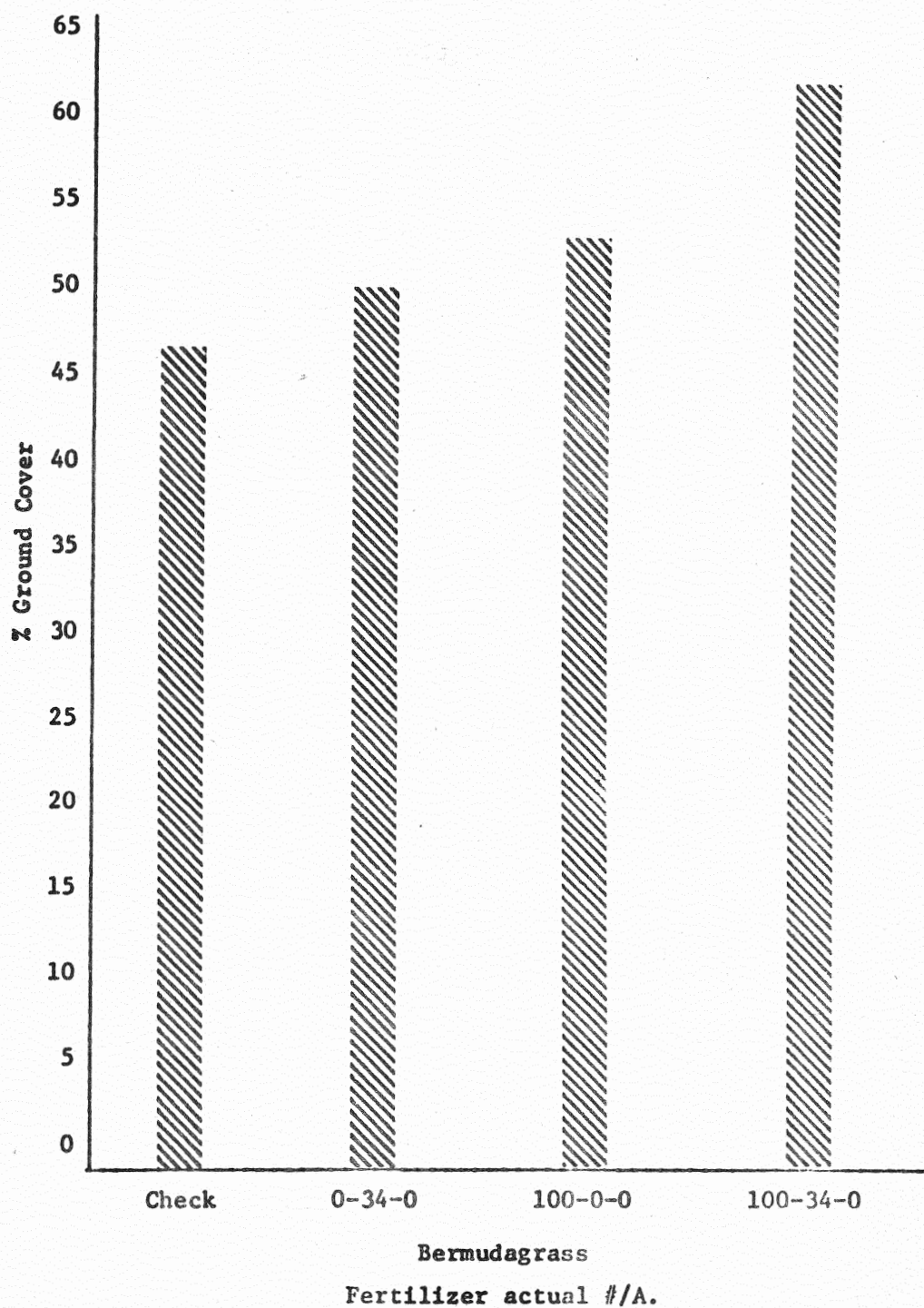


Figure 41. The effect of various fertilizers applied July 14, 1966, and again on July 21, 1967, on the growth of bermudagrass on an east facing fill slope on SH-34, 6.8 miles north of US-64 west of Alva, Oklahoma.

about seven percent more in those plots that received 34 pounds of phosphorus in addition as shown in Figure 42. More bermudagrass is found on this warmer, west facing slope than on the cooler, east side. Only the plots that received phosphorus fertilizer alone on the west side had less ground cover than the plots on the east and it was only about two percent less than the check.

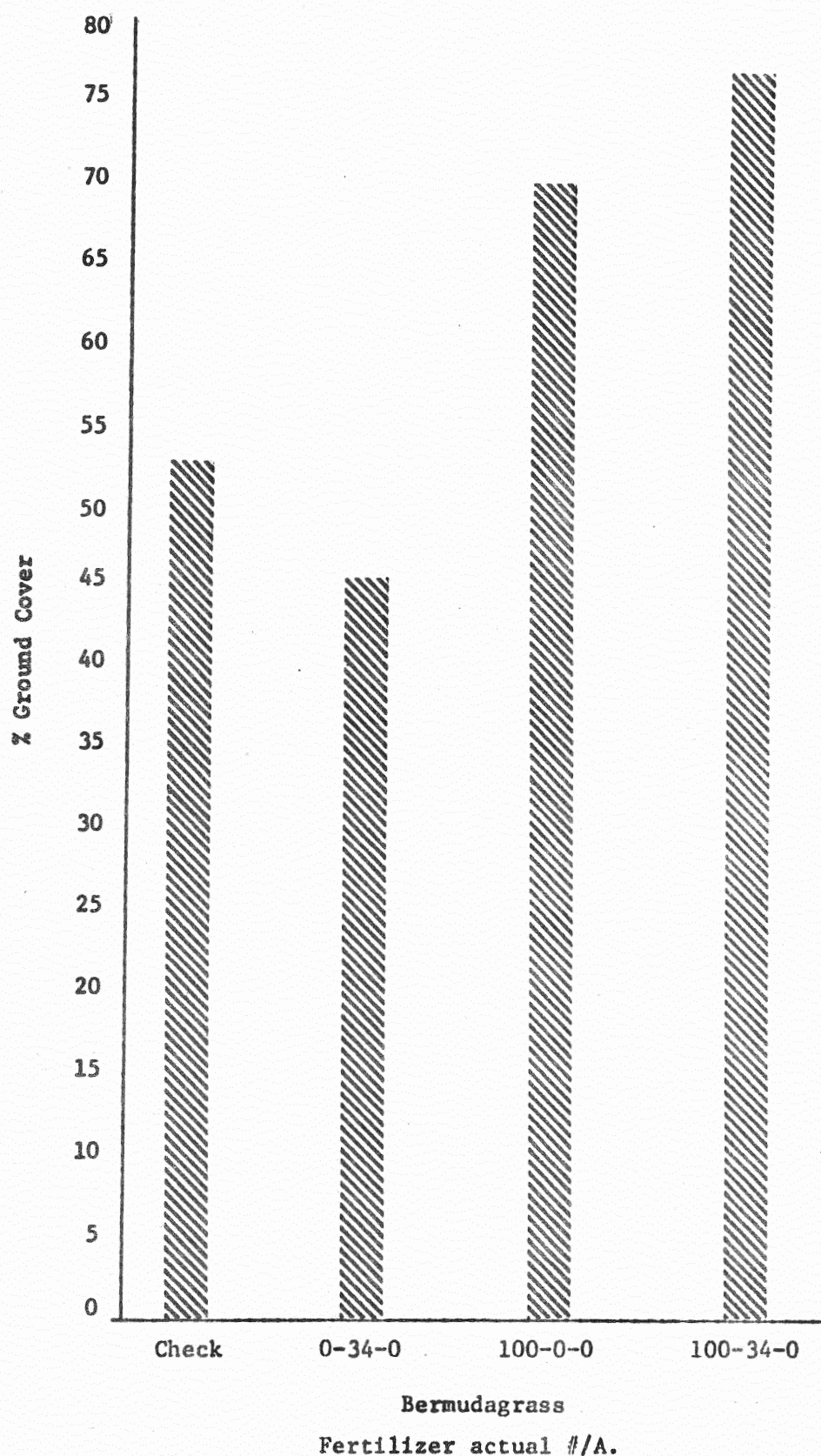


Figure 42. The effect of various fertilizers applied July 14, 1966 and again on July 21, 1967, on the growth of bermudagrass on a west facing fill slope on SH-34, 6.8 miles north of US-64 west of Alva, Oklahoma.

PART III
WEED CONTROL AND ERADICATION
ON
OKLAHOMA HIGHWAYS^{4/}

INTRODUCTION

The highway program in Oklahoma requires modern, efficient methods of establishment and maintenance of desirable vegetation on the rights-of-way if it is to provide maximum services with a minimum of expenditure. More than 15,000 miles of state and federal highways and roads are presently maintained by the Oklahoma Department of Highways. Herbicides are being used successfully in most areas to minimize hand labor in the maintenance programs around guard-rails and signposts, to reduce the frequency of mowing, and to improve the effectiveness and reduce the costs of weed control on grass covered areas.

The roadside weed control research is concerned both with selective and non-selective herbicides for the control of undesirable grasses and broad-leaved weeds. The investigations although with the common objective of weed control were divided into three parts as follows: I Broadleaf weed and annual grass control, II Soil sterilization, and III Johnsongrass control.

^{4/} In order that the information in this publication may be more useful, it was sometimes necessary to use tradenames of products, rather than complicated chemical identifications. As a result it is unavoidable in some cases that similar products which are on the market under other tradenames may not be cited. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

PREVIOUS FINDINGS AND RECOMMENDATIONS^{5/}

The evaluation of herbicides for the most effective and economical means of weed control on the highway system is a continuous process. Numerous herbicides currently available and combinations of these have been only partially evaluated, some of which could be more effective and economical than the ones currently recommended. Each year new herbicides are developed and should be evaluated immediately if maximum efficiency and economy in weed control on the highway system is to be achieved. Recommendations for weed control and eradication based upon these initial findings must be subject to revision with the accumulation of additional data.

BROADLEAF WEED AND ANNUAL GRASS CONTROL

1. Sandbur Control. The post-emergence herbicides ammonium methanearsonate (AMA), calcium acid methyl arsonate (CMA), monosodium acid methanearsonate (MSMA), and disodium methanearsonate (DSMA) each with one retreatment 7 to 20 days after the initial application are equally effective in the control of sandburs on Oklahoma highways. A surfactant should be added at the rate of one percent by volume to those materials that do not contain a surfactant in the manufacturers formulation. These herbicides should be applied in enough water to make 40 gallons of solution per acre plus 0.4 gallon of surfactant as needed.
2. General Broadleaf Weed and Annual Grass Control. The pre-emergence application of atrazine is recommended first for the control of both

^{5/}Huffine, Wayne W., Lester W. Reed and Gary W. Roach. 1968. Weed Control and Eradication on Oklahoma Highways. Final Report, Oklahoma Project 63-03-3, Roadside Development and Erosion Control. Part III. Oklahoma State University.

broadleaf weeds and annual grasses commonly found on Oklahoma highways. Diuron, although not as widely effective in these experiments, is the second pre-emergence herbicide recommended for both broadleaf weed and annual grass control. To control only broadleaf weeds the herbicide dicamba (Banvel-D), 2,4-D amine, and 2,4,5-T are recommended.

3. Alfalfa and Sweetclover Control. The herbicides recommended for the control of these plants on the highway system are 2,4-D amine, 2,4,5-T amine, and dicamba (Banvel-D).

JOHNSONGRASS CONTROL

The organic arsonate herbicides disodium methanearsonate (DSMA), and monosodium acid methanearsonate (MSMA) are recommended for the selective control of johnsongrass on Oklahoma highways. These herbicides should be applied two or three times per year in enough water to make 40 gallons of solution per acre plus a surfactant at the rate of one percent by volume with those materials that do not contain a surfactant in the manufacturers formulation. The most effective control of johnsongrass will be obtained with these herbicides when the plants are treated when 12 to 18 inches tall and actively growing, and when the sun is bright and the temperature is 80°F or higher.

SOIL STERILIZATION

The herbicides recommended for the suppression of all plant growth, especially bermudagrass on shoulders and under guardrails of the Oklahoma highway system are bromacil, borocil, TCA Inhibited, Borea T-10, and a combination of TCA and bromacil.

RESEARCH
ON
WEED CONTROL AND ERADICATION

The principal objectives of this part of the research project were to find the most satisfactory and economical methods to control weeds on the Oklahoma highway system. To achieve these objectives several factors were to be evaluated. The major items of concern involved chemical and mechanical means of weed control, and were to concentrate on:

A. Chemical control of weeds.

1. The evaluation of selective herbicides for weed control.
2. The evaluation of non-selective herbicides for soil sterilization.
3. The evaluation of chemical growth regulators as a substitute for mowing.

B. Mechanical control of weeds.

1. Determination of proper time to mow for weed control in each geographical area of the state.
2. Determination of proper height and frequency of mowing required for weed control in various highway areas.

The results presented in this report are supplemental to and in support of the research described in the Final Report, Part III, of the Oklahoma Project No. 63-03-3 on Roadside Development and Erosion Control, prepared in 1968 dealing with "Weed Control and Eradication on Oklahoma Highways".

FINDINGS AND CONCLUSIONS

The roadside weed control research in Oklahoma is concerned both with selective and non-selective herbicides for the control of undesirable grasses and broadleaved weeds. The investigations although with the common objective were divided into three parts as follows: Part I Broadleaf Weed and Annual Grass Control; Part II Soil Sterilization; and Part III Johnsongrass Control.

Residual activity of those herbicides evaluated for the control of broad-leaf weeds and annual grasses (Part I), or the eradication of johnsongrass (Part III) was not readily distinguishable a year or more after application, as many were post-emergence types of chemicals effective only when applied on actively growing vegetation. On the other hand, those chemicals included in the investigations of soil sterilization (Part II) were generally expected to persist for a reasonable period of time. As a result of the cost of application from only the labor involved, it would be desirable from an economic standpoint, if the herbicides would persist for an extended period of time.

Research results dealing with the evaluation of herbicides for complete plant suppression or soil sterilization are the only data to be presented in this part of the report. Evaluations of herbicides in the other aspects of the research on weed control and eradication were not possible after an extended length of time following application.

SOIL STERILIZATION

The plant species commonly found and oftentimes quite difficult to control on Oklahoma highways is common bermudagrass (Cynodon dactylon). This plant becomes troublesome on the highway shoulders particularly when the rhizomes or shoots break through the asphaltic surface and open a channel for water penetration into the roadbed.

In the experiment located near Chickasha on SH-92 (3.2 miles north of US-62) 12 chemicals were applied in March 1965 and retreated at one-half the original rate in June 1966. When evaluated in March 1969 no significant differences could be detected in the treatments. As shown in Figure 43 borocil, TCA, bromacil, and prometone each provided more than 50% control of bermudagrass on the shoulder three years after the last application. This is in agreement

% Bermudagrass Control

0 10 20 30 40 50 60 70

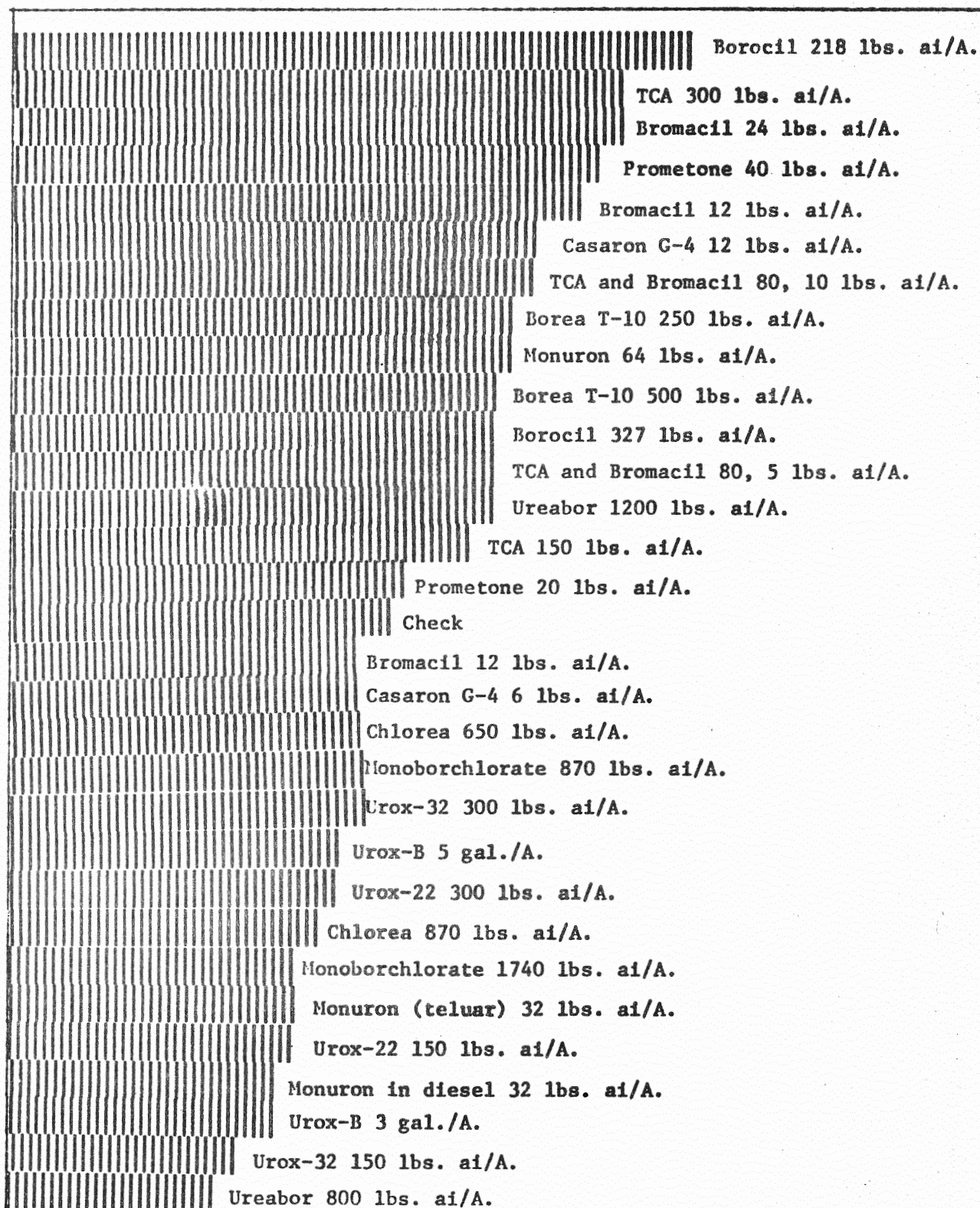


Figure 43.

The effect of various chemicals applied on March 26, 1965, and retreated at one-half rate June 17, 1966, in the control of bermudagrass on SH-92 shoulders near Chickasha, Oklahoma as evaluated on March 21, 1969.

with and support of the results reported on page x of the Final Report of Oklahoma Project No. 63-03-3, Part III.

In the experiment initiated in June 1965 on SH-99 near Wynona in north-central Oklahoma a highly significant difference in herbicide treatments was found. The best materials as shown in Figure 44 providing more than 50 percent control of bermudagrass were bromacil, prometone and Urox-22. The bromacil treated plots showed about 65% control of the bermuda.

An experiment was initiated in December of 1965 on US-177, about five miles south of the US-66 intersection west of Chandler, in central Oklahoma to evaluate several chemicals as soil sterilants and the effects of their application in mid-winter. The results of this experiment are shown in Figure 45. A significant difference was found in the treatments and their effect on bermuda. Those chemicals that exhibited more than 50% control of the bermudagrass included borocil, monuron, Urox-HX, ureabor, Borea T-10, bromacil, and prometone. These data support the recommendations shown on page x of the Final Report of Oklahoma Project No. 63-03-3, Part III. The herbicide prometone has exhibited good persistence and effectiveness by more than 50% control of bermudagrass in these three experiments and should be considered for use as a soil sterilant in the maintenance program on Oklahoma highways. A combination of this chemical with perhaps a fast-acting material such as TCA-Inhibited would be more satisfactory and economically feasible.

% Bermudagrass Control

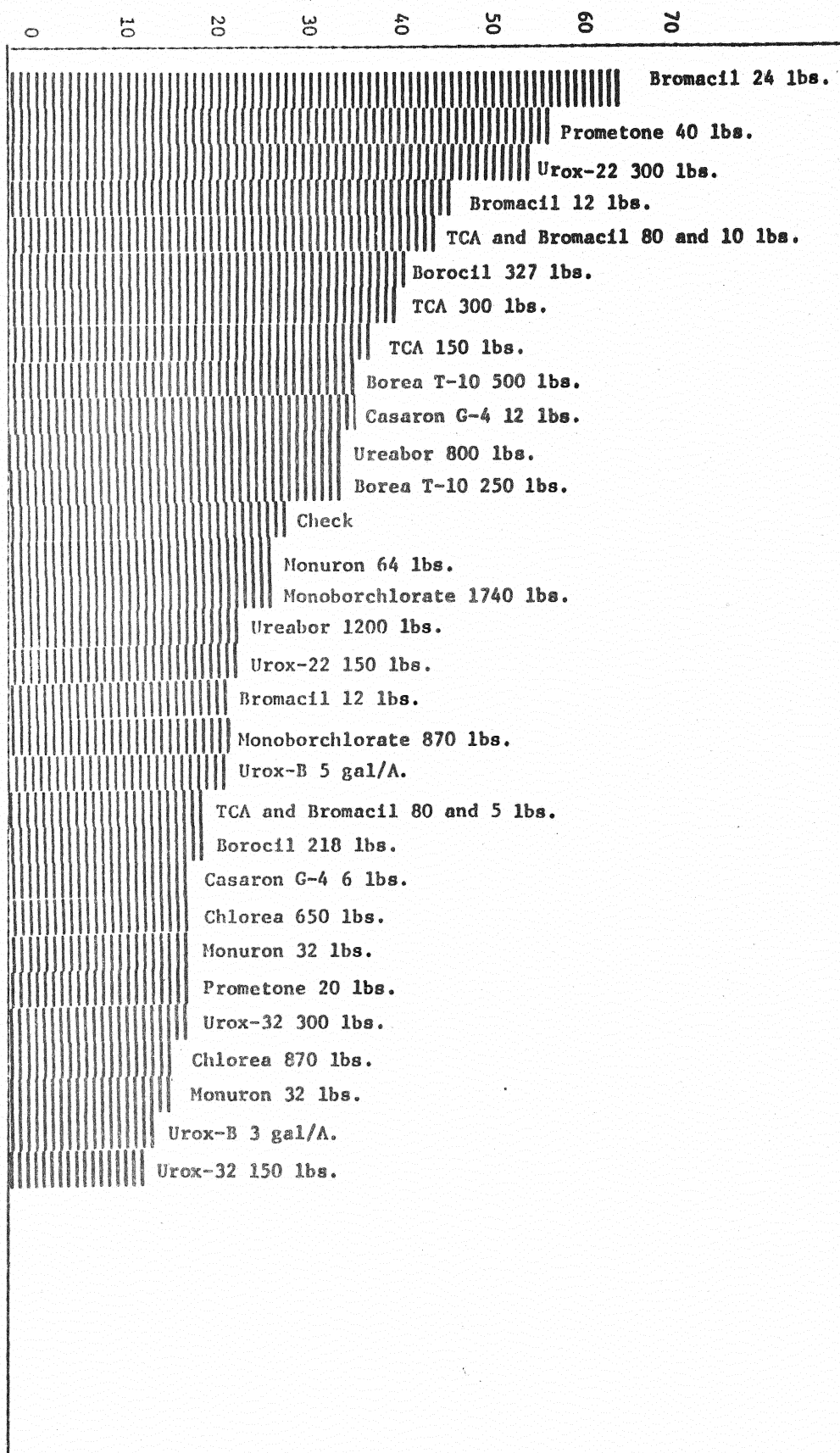


Figure 44. The effect of various chemicals applied on March 30, 1965, and retreated at one-half rate June 15, 1966, in the control of bermudagrass on SH-99 shoulders near Wynona, Oklahoma as evaluated April 25, 1969.

Chemical and rate in pounds ai per acre

Chemical and rate in lbs. ai/A.

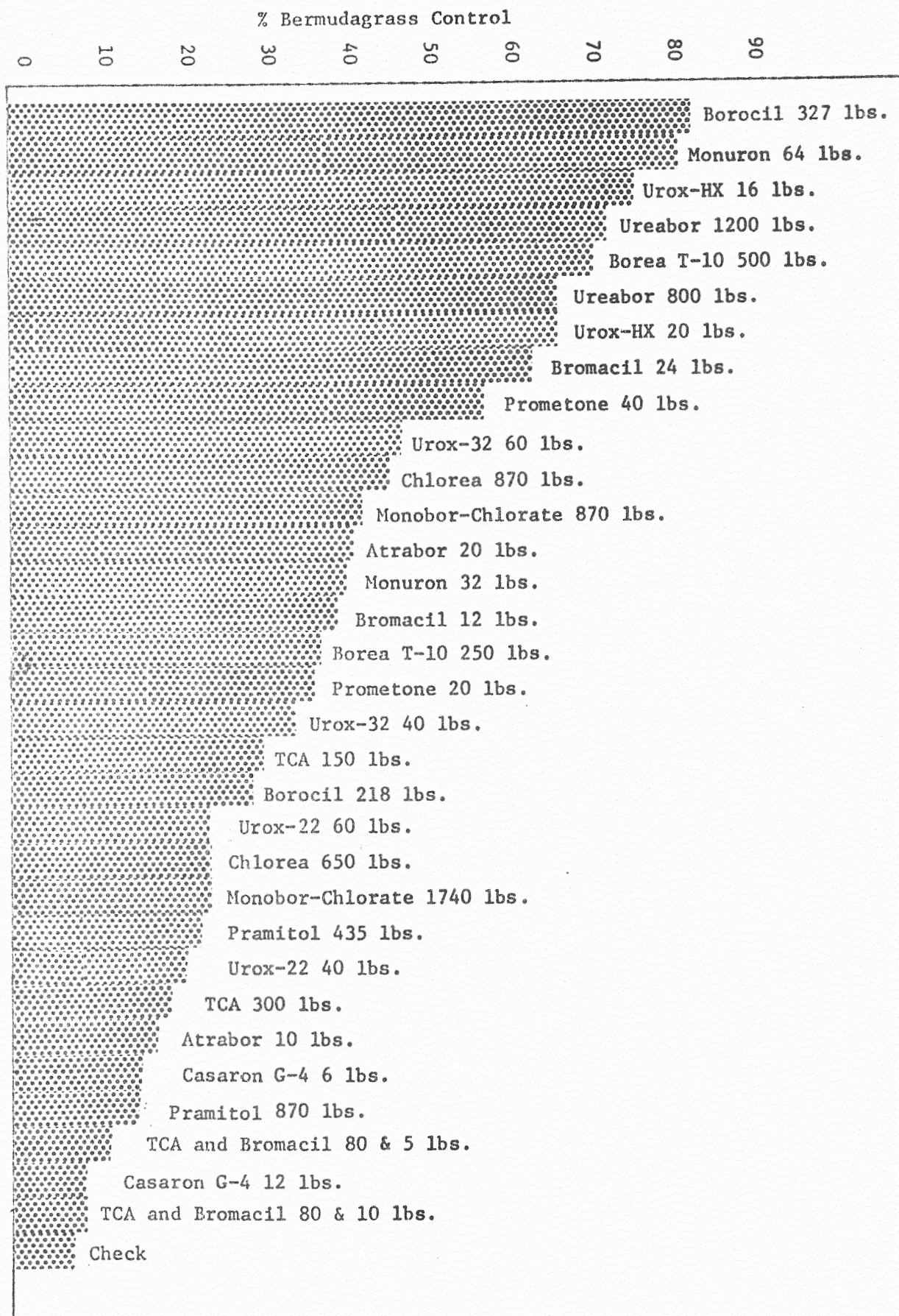


Figure 45. The effect of various chemicals applied November 30, 1965 on the control of bermudagrass on U.S. 177 shoulders 4.8 miles south of U.S. 66 junction in central Oklahoma as evaluated March 24, 1969.

APPENDIX

Chemicals Included in the Weed Control Experiments

Herbicide	Chemical, Form, and Concentration
Urox	3-(p-chlorophenyl)-1,1-dimethylurea trichloroacetate
Urox HX	Bromacil (5-bromo-3 sec-butyl-6-methyluracil) granular 4%
Urox-22	(Same as urox) granular 22%
Tordon	4-amino-3,5,6-trichloropicolinic acid liquid 2 lbs. per gallon
Betasan 4E	S-(0,0-diisopropyl phosphorodithioate) of N-(2-mercaptoethyl) benzenesulfonamide liquid 4 lbs. per gallon
Betasan	(Same as Betasan 4E) granular
Banvel-D	2-methoxy-3,6-dichlorobenzoic acid liquid 4 lbs. per gallon
Chlorea	Sodium chlorate 40% Sodium metaborate 51% Monuron 2.4% granular 93.4%
Prometone	2-methoxy-4,6-bis-(isopropylamino)-S-triazine liquid 2 lbs. per gallon
Dacthal	dimethyl 2,3,5,6,-tetrachloroterephthalate wetable powder 75%
Atrabor 8p	atrazine granular
Fenac	2,3,6-trichlorophenylacetic acid liquid 2 lbs. per gallon
TCA	trichloroacetic acid soluble powder to be applied with water Inhibited 91%
Simazine	2-chloro-4,6-bis (ethylamino)-S-triazine wetable powder 80%
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-S-triazine wetable powder 80%

Monuron	3-(4-chlorophenyl)-1,1-dimethylurea wetable powder 80%
Diuron	3-(3,4-dichlorophenyl)-1,1-dimethylurea wetable powder 80%
Dalapon	2,2-dichloropropionic acid wetable powder 85%
Casoron	2,6-dichlorobenzonitrile granular
MSMA	Monosodium acid methanearsonate liquid 2 lbs. per gallon
MBC	Sodium metaborate 68% Sodium chlorate 30% (Boron trioxide 23%)
Ureabor	Disodium tetraborate pentahydrate 63.2% Disodium tetraborate decahydrate 30.0% (Boron trioxide 41.4%) Monuron 2%
Borocil	Disodium tetraborate pentahydrate 71.2% Disodium tetraborate pentahydrate 22.8% Bromacil 4.0% granular
Borea T-10	Sodium metaborate 50% Monuron 8% granular
AMA	Ammonium methanearsonate liquid 1.4 lbs. per gallon
DSMA	Disodium methanearsonate Wetable powder 63%
2,4D	Dimethylamine salt of 2,4-dichloroacetic acid liquid 4 lbs. per gallon
2,4,5T	Triethylamine salt of 2,4,5-trichloroacetic acid liquid 4 lbs. per gallon